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AN ANALYSIS OF THE F-16 AIRCRAFT REQUIREMENTS GENERATION PROCESS AND ITS ADVERSE IMPACT ON CONTRACTOR RATE CAPACITY

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LSSR 74-82

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The United States defense industry is experiencing frustration in agglomerating planned Department of Defense production requirements. One probable source of this frustration is inadequate requirement forecast consolidation by the Department of Defense. Several agencies within the Department of Defense are charged with procuring subassemblies and spares for major weapons systems. In the case of the United States Air Force F-16, the Air Force Logistics Command and the Air Force Systems Command are involved in formulation of production requirement forecasts, and may do so independent of one another. Defense suppliers are then subjected to a myriad of unconsolidated forecasts, none of which they can satisfy without significantly reducing their ability to fulfill other demand requirements. Methods, therefore, should be developed to improve the requirement forecast consolidation process. By examining the requirement sources for the F-16, and interviewing key acquisition personnel at the Air Force, prime contractor, and subcontractor levels, several methods to improve requirement consolidation become evident.

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AN ANALYSIS OF THE F-16 AIRCRAFT REQUIREMENTS GENERATION PROCESS AND ITS ADVERSE IMPACT ON CONTRACTOR RATE CAPACITY

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirement for the

Degree of Master of Science in Logistics Management

By

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September 1982

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Leslie M. Norton
COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

Statement of the Problem

The United States Defense Industry is experiencing frustration in agglomerating planned Department of Defense production requirements. One probable source of this frustration is inadequate requirement forecast consolidation by DOD. Several agencies within DOD are charged with procuring subassemblies and spares for major weapons systems. In the case of the United States Air Force F-16, the Air Force Logistics Command (AFLC) and the Air Force Systems Command (AFSC) are involved in formulation of production requirement forecasts, and may do so independent of one another. Suppliers are then subjected to a myriad of unconsolidated forecasts, none of which they can satisfy without significantly reducing their ability to fulfill other demand requirements. As a case in point, a subcontractor may have an order to fill for the prime contractor from AFSC. At the same time he may have to fill a spares order from AFLC. If the subcontractor's production capacity was limited, whose orders would be filled?

This thesis revolves around the demand forecast processes of the USAF F-16, a major weapon system. A major weapon system is a highly complex unit of military hardware that requires substantial field support to keep it operational. Without an adequate supply of spare parts, any weapon system is soon rendered useless. It is estimated that of the 79 F-14 aircraft bought by Iran, fewer than 6 were flying less than 2 years after the United

States terminated spare parts delivery (36). Even with the higher reliability of components, which should reduce the need for spare parts, as weapons systems become technologically advanced their support requirements increase dramatically. This increase in technological sophistication has made production a critical process, and has resulted in manufacturers needing more and more time to produce the spares. Because many parts are of a highly technical, specialized nature, often only a single contractor is financially and logistically capable of producing a given spare part. Thus, the Air Force has found itself increasingly dependent on single source contractors for the delivery of critical spare parts. Therefore, difficulties experienced by the contractor soon become Air Force difficulties.

Justification

This thesis supports the proposition that a consolidated requirement forecast is essential for industrial efficiency and the timely production of components. Requirement forecasting is a critical element of any business organization. Forecasts play a significant role in almost every decision made in the company. Finance departments use forecasts to ensure adequate cash flow, while production departments use them for planning production runs, scheduling particular jobs, and insuring sufficient levels of inventory (1:67).

The value of forecasting is seen not only in the number of forecasting models available, but also in their varying degree of sophistication and continual state of refinement. Forecasts can be subjective or based on the precept that past demand can be used to predict future demand. Other types of forecasts assume demand is based on environmental factors. The use of computers allows simulation models to compute demand by thoroughly analyzing hundreds of variables (1:68).

The benefits of accurate demand forecasts are several fold. Accurate forecasts enable planners to schedule orderly and uninterrupted production runs. Conversely, unprojected demands force the manufacturer into a reactive rather than planning stance, and will usually result in shorter production runs. These short production runs then result in higher prices because of hiring and layoff costs, as well as start-up costs. Given an accurate forecast, the production planner can identify plant requirements to meet the forecasted demand, and adjust accordingly. An accurate, accepted long range demand would encourage the business to expand capacity.

The Department of Defense would also realize several benefits. A consolidated order that covered independent agency requirements would result in quantity order savings. Production cost, as well as production time, would be reduced. A consolidated requirement forecast would show a larger demand over the long run than the conventional unconsolidated demand forecasts. The projected quantity increase may encourage manufacturers to bid on contracts, which would result in the Air Force receiving the price benefits induced by competition. There certainly exists room for improvement in the area of competition. In FY81, 41% of the Air Force new contract awards were to sole source contractors (49). An additional 1.57 billion dollars worth of new contracts were follow-on contracts (49). Follow-on contracts are essentially sole source, since it takes a new supplier 12-18 months to tool up and begin production, even with a reprocurement data package (19:130; 39).

With the aid of accurate requirement forecasts, when limited production runs are unavoidable, military departments would be able to allocate

production to critical areas, such as applying a higher priority to replenishment spares than to War Reserve Material. Additionally, the military would realize benefits in FMS cost recoupment. One condition for all foreign military sales is that they be conducted at no cost to the government. To satisfy this condition, the government charges the foreign country a fee for administrative costs as well as non-recurring research and development costs. Under the present system where both AFSC and AFLC provision for foreign military sales, identification of actual costs incurred by the U.S. government is a cumbersome and not all together accurate process. A consolidated demand forecast would allow for the specific identification of FMS related production and support activity costs.

Large production runs also provide contractors with various incentives to reduce costs, and thus increase profits. With uncertain requirement forecasts, manufacturing firms are reluctant to invest large sums of capital at high interest rates to support the product. On the other hand, the certainty of a constant and long production run provides the incentive for innovations designed to cut costs. The Value Engineering Change Proposals and the Technical Modernization programs provide just such incentives. The incentives of these programs are similar to those found in the Reliability Improvement Warranty (RIW) program. In the RIW program, incentive oriented contracts give contractors the impetus to reduce costs by increasing reliability, thus reducing repair costs, with the savings initially their profit, and later saving the Air Force dollars in reduced maintenance costs (32; 38).

The lack of a requirement forecasting consolidation mechanism is a problem identified by both Industrial Preparedness Planning (IPP) Studies and by key personnel working with the F-16 Systems Project Office (SPO).

As the background shows, numerous and ofter independent demands placed upon contractors disrupts production schedules. This, in turn, results in difficulties in maintaining production runs and delivery schedules.

Major Lyle W. Lockwood, the F-16 SPO Multi-National Manufacturing Manager, identified the lack of demand forecasting consolidation as a critical problem during his study of the F-16 industrial base capacity and lead time analysis (32). This view is shared by Captain Donald L. Brechtel, who had previously been involved in similar F-16 manufacturing problems (13).

Research studies have also identified this independent demand problem. They have found there is no single focal point for consolidating demand requirements for a particular part of a system purchase (12). This report also states that contractors were not always provided with total demand requirements; rather, requirements were fed to the contractor on a piece-meal basis. Finally, inconsistencies were noted between requirements for the same component by various organizations (12).

An Independent Support Capability Study suggests further studies be conducted focusing on methods of providing contractors with a better definition of requirements and alternatives (21:52). The study stressed that DOD spare parts schedules should include all service requirements, and that the vendor evaluation must include consideration of the vendor's other production requirements (21:34).

Purpose of Research and Research Questions

The purpose of this research is to identify and describe the present requirements forecasting process, along with its limitations, and to recommend proposals to correct noted deficiencies. It is intended that the

methodology of this research be generalized and applied to other major AF acquisitions. This research hypothesizes that there is a lack of demand forecasting consolidation within the Air Force regarding the F-16, which adversely impacts subcontractor production planning. To explore this hypothesis three research questions must be answered:

1. What are the sources of materiel requirements, and the methods used to forecast these requirements?

2. What are the quantitative and qualitative aspects (characteristics) of the requirements generation methods?

3. How are these demand forecasts communicated to the defense industry?

Limitations and Assumptions

This research is conducted under the following limitations and assumptions:

Limitation 1. The impact of coproduction on available supply has been ignored. Although it does affect parts availability, it is too complex an area to address in this study.

Limitation 2. This thesis is limited in scope to several critical F-16 subassemblies rather than all aircraft subassemblies.

Assumption 1. All demand forecasting methods reviewed are considered appropriate and adequate to serve the purpose for which they were designed. Although this study will examine various aspects of forecasting models, it will not assess or determine their adequacy.

Literature Review

An exhaustive and thorough literature review was conducted to identify the requirement's sources within the Air Force. This review centered primarily on appropriate regulations such as ATCR 65-1, Ground Training and Support Equipment, Spares/Repair Parts Provisioning, and AFR 400-24, War Reserve Materiel Policy. Additionally, manuals and command pamphlets such as AFM 67-1, USAF Supply Manual, and AFLCP 57-3, Recovery Inventory Control using MOD-METRIC were consulted. Where no specific guidance was available, information was obtained through both personal and telephone interviews. Other additional sources of information were provided by a review of DOD logistics models, DOD documents, and Rand Corporation reports, such as METRIC, MOD-METRIC, and Dyna-METRIC. Last, the Defense Logistics Information Exchange provided numerous published and unpublished research reports concerning the diverse area of Production/Rate Capacity Planning, and the National Defense's Industrial Base.

General Research Plan

The justification section of this chapter provides adequate documentation of the problems associated with unconsolidated and inaccurate requirement forecasts. We contend that the unconsolidated and independently derived requirement forecasts made by the Air Force create several problems for industry. Our initial efforts will be to identify the various requirement forecasting sources within the Air Force, and in particular, those associated with the F-16 aircraft. This will be accomplished by conducting an exhaustive literature review, and through personal interviews where needed. A brief review of each requirement is presented in

Chapter II. Thus having documented a summary of the mechanics of requirements generation, several critical components/subassemblies will be selected and used as case studies to verify both the application of the models by the Air Force, and how contractors receive the requirement forecasts. These case studies will necessitate interviews with F-16 item managers at the Air Force Air Logistics Centers, and production personnel at the prime contractor and subcontractor levels.

Interview responses will be analyzed by question, and, along with the findings of the interviews, will comprise Chapter III. Chapter IV will include our summary of findings, conclusions, and recommendations.

Research Methodology

The literature review shows that Air Force generated demand requirements originate from a variety of sources using independent computational methods. This paper will conduct a field examination to determine whether unconsolidated and independently derived demands place unnecessary hardships on the production capabilities of industry. Should this prove to be the case, we will propose recommendations designed to eliminate these problems.

Field Survey. To determine if demand forecast consolidation is a problem in the Air Force, it will be necessary to conduct a field survey of those participants in the parts procurement process who would most likely experience the problem. The most obvious candidate is the manufacturer. In the case of the F-16, there are two types of manufacturer: the prime contractor (General Dynamics), and the subcontractors. Since each type of manufacturer may experience unique problems, it will be necessary to

interview both types. Manufacturers, however, are not the only participants in the procurement process. To insure that views are not entirely one-sided, Air Force agencies that interact with these manufacturers will be interviewed regarding requirements consolidation during the procurement process. The combined results of these interviews will be used to verify or reject our hypothesis that the demand forecasting process is unconsolidated and adversely impacts the Air Force and the U.S. industrial base.

Item Selection. To promote continuity within the investigation, requirement forecasts will be limited to a select group of end items. Item selection is constrained by both time and money. As such, selection is based primarily on convenience of accessibility. Attempts will be made to focus on critical items, and items that possess the greatest exposure to the demand requirements listed in Chapter II. Additionally, it is intended that items represent a cross section of F-16 subsystems.

Interviews. The data collected for analysis will be accumulated from personal and telephone interviews conducted with both Air Force item managers and manufacturers. A representative sample of manufacturers includes both prime and subcontractors. Since this study does not attempt to draw statistical inferences from the sample population, the sample of manufacturers has been drawn for convenience.

Interviews will be conducted both in person and by telephone. Questions posed will be open-ended in nature, and have been approved by experts within the manufacturing areas as appropriate. It is the intent that question responses not be quantifiable for statistical analysis. Rather, it is hoped they reflect an accurate portrayal of the procurement process.

Additionally, the questions asked to both Air Force and manufacturing sources (demand and supply side) will be similar in content to facilitate data analyses.

A list of questions for Air Force sources can be found in Appendix E, with questions posed to manufacturers found in Appendix F.

Data Analysis. Question responses will provide the data to be analyzed. Responses to similar questions asked to both Air Force and manufacturers will be discussed in detail. Attention will focus, for instance, on the degree of requirement forecast consolidation, and the problems that manufacturers face as a result of order arrivals. Problem areas noted will provide the basis for recommendations to improve this procurement process.

CHAPTER II

A REVIEW OF F-16 REQUIREMENT GENERATION SOURCES

Introduction

The review of the literature identified a number of demand sources for F-16 spare parts. The Air Force initially makes use of interim contractor support to satisfy testing requirements until initially provisioned items are available within the Air Force supply system. As the weapons system is deployed in the field, initial levels of spares are acquired based on levels set forth in the Initial Supply Support List. After initial deployment, repair cycle computations provide demand forecast data for recoverable items. Aside from this mainstream of spare part requirements lie several other demand sources. War Readiness Material (WRM) requirements must be satisfied. WRM consists of War Reserve Supply Kits, Base Level Self Sufficiency quantities, and Other War Readiness Material. Foreign military sales are also a drain on the parts supply. Air Force training programs require the same kind of spare parts as are used on the end item. There also exists the need to retrofit any parts for which modifications have been designed. Finally, some parts which have failed must be contracted out for repair. Each of these demand sources place a drain on the F-16 asset pool. This literature review will examine these demand sources, showing how each requirement is computed, and by whom. The appendices provide specific examples of how several of the major demand requirements are derived.

Interim Contractor Support

Interim contractor support (ICS) is the use of contractor support for providing spares and support equipment for a new weapons system during the early stages of the weapons system acquisition process. ICS is authorized under two conditions:

(1) When the support items have an unstable design; thus the costs of setting up organic capability at the time the support is first required are excessive.

(2) All or part of the resources required for an organic capability will not be available until after operational support is required (47:1).

The Air Force generally plans to have organic support vailable by the time operational units are first deployed; however, this may not always be possible. The initial acquisition of spares requires a substantial investment on the part of the Air Force. During the early phases of the weapons system acquisition process there was substantial risk of design changes occurring in the F-16 avionics systems. If the Air Force invested heavily in this early design materiel, it would have exposed itself to the risk of obsolescence or modification. To avoid this risk where practical, the Air Force made use of ICS.

During the demonstration and validation phase, the F-16 Program Manager (PM) and the Deputy Program Manager for Logistics (DPML) conducted risk analyses through the logistics support analysis process. Using these risk analyses the PM and DPML identified specific items to be considered for ICS. This item list was refined during full-scale engineering development, and contracted for during the production and deployment

phase (47:9). Therefore, the Air Force investment in high risk items was deferred until the design specifications were somewhat stabilized. To determine the most cost effective approach to ICS, the Air Force compared prime contractor cost estimates to the actual manufacturer's estimates (47:5). It should be stressed that ICS is an interim procedure designed for use only until organic supply support capability is available. This organic capacity is established through provisioning.

Provisioning Requirements

Whenever a new weapon system such as the F-16 enters the Air Force inventory, supply support for that system must be provisioned. Initial provisioning is defined by AFLC as the "management process for determining and acquiring the range and quantity of support items necessary to operate and maintain an end item of material for an initial period of service" (7:1-1). The initial period of service extends from the preliminary operational capability (POC) date through the item lead time, plus three months, or a minimum of 12 months (6:1-1). The purpose of initial provisioning is to achieve the maximum peacetime support of initial spares and repair parts, with the emphasis on reducing supply response time with a minimum, but adequate range and depth of spare stockage (14). This simply means laying in an adequate quantity of material, when and where needed, and within monetary constraints, to support an end item until normal resupply can be effected (4:19-1;12).

After the weapons system contract is awarded, a guidance conference between the contractor and the Air Force is held (7:6-1). During this conference, the Air Force and the contractor begin provisioning determinations. These determinations are made for each individual line

item, from large components to the smallest nut, bolt, and screw. These line items are either presently in the Federal Supply System, in which case they are identified by a National Stock Number (NSN), or they are new to the supply system, and must have an NSN assigned. During the subsequent provisioning process the system manager determines which line items will be stocked by the Air Logistics Centers (ALC). Line items possessing an NSN have demand data and stock levels already available. The IM reviews current stock levels and demand rates to develop a new projected demand. The ALC then contracts for the additional requirement.

Line items not possessing a valid NSN are researched for suitable substitutes or valid NSNs through the Defense Logistics Services Center (7:8-1). If no NSN is found, the line items must then be initially provisioned. Initially provisioned items are new to the Air Force inventory, and are procured in advance of actual demand use information. Since there is no prior experience upon which to base supply levels, the Air Force determines a "best guess" supply level, which primes the supply pump. For stock fund items (XB3, XF3) the Air Force formulates initial provisioning requirements based on the EOQ principle, using cost and inventory data from similar items in the supply system (8:9). For investment type items (XD1, XD2, XD3) the Air Force bases its best guess on the contractor's estimate of the component's mean time between failure (MTBF), mean time to repair (MTTR), the replenishment cycle time (RCT), and the lead time for procurement. Using this information, the equipment specialist projects initial maintenance requirements by assigning maintenance and overhaul

factors to each item. The equipment specialist will determine the following factors:[2]

(1) Maintenance factor

(2) Overhaul replacement percent

(3) Base condemnation percent

(4) Depot condemnation percent

(5) Not reparable this station percent (NRTS)

Initial Spares Support List

When initial provisioning is not, or no longer authorized, initial spare support is provided through the initial spare support list (ISSL). The ISSLs, developed during the provisioning process, are lists of spares and repair parts required for the support of end items at the base level. Spares (XD1, XD2, XF3) are items which are reparable. Repair parts (XB3) are not in themselves reparable, but are used in the repair of spare parts or the end item (45:12-5, 12-33). The selection of which spare and repair parts will be included in the ISSL is conducted by the responsible ALC equipment specialist along with inputs from the IM, SM, the using command, and/or the contractor during the provisioning process (45:12-33).

The ISSL quantity for spares is computed as the base order and shipping time quantity (to compensate for pipeline time) plus the base repair cycle time quantity.[3] The ISSL repair item quantity is limited to the base order and shipping time quantity, since no repair is effected on repair items.

---

[2]See Appendix B for explanation of these factors.

[3]For exact explanation of how this quantity is determined, see Appendix B or AFLCR 66-68.

These ISSL quantities will then be input into the Standard Base Supply System (SBSS) computer program as the base demand level. These demand levels are then retained for 2 years from the activation of the weapons system. After this 2 year period, actual demand levels are used.

Repair Cycle Requirements

After initial quantities of repair items (such as those identified in the ISSL) have been delivered to the base, some method must be employed to insure that an adequate supply of spare parts is always available to support mission requirements. How much constitutes "adequate" is determined by the SBSS computer package.

Demand levels for repair cycle items are locally determined by adding the base repair cycle quantity, the order and shipping time quanitity, the NRTS condemnation quantity, and a safety level, and applying a + .5 adjustment factor for units costing $750.01 or more, and a + .9 adjustment factor for those costing less.

Bases place demands for repair cycle assets on the Air Logistics Centers. Within the ALCs, the appropriate IM will supervise procurement of repair cycle assets using the D041 computer system as his primary management tool. Demand levels for stock fund and local purchase items are based on an EOQ policy (45:11-1 to 11-8).

War Reserve Materiel Requirements

In addition to normal resupply materials, the Air Force must maintain emergency wartime stocks. These emergency stocks are called War Reserve Materiel. Specifically, War Reserve Materiel (WRM) is that materiel required in addition to peacetime assets to support the planned wartime

activities reflected in the USAF war and mobilization plan (5:1; 45:14-10). WRM consists of War Readiness Spares Kits, Base Level Self-Sufficiency Spares, and Other War Readiness Materiel.

War Readiness Spares Kits (WRSK) for the F-16 aircraft are air transportable packages of WRM spares, repair parts and related maintenance supplies required to support planned wartime or contingency operations of a weapons system for a specified period of time (45:14-10). Base Level Self-Sufficiency Spares (BLSS) are WRM spares and repair parts intended for use as base support for operational units which plan to operate in place during wartime, considering the available maintenance capability (45:14-8). Other War Readiness Materiel (OWRM) are supplemenal spare parts planned to augment WRSK and BLSS until P-Day (the date production can satisfy consumption) or until the end of the wartime scenario (33). AFLC develops the computational techniques and formula to support WRM policy concepts. These techniques are coordinated with MAJCOMs and HQ USAF/LEY before they are used (46:1-4).

Two methods exist to compute the number of each item to be placed in a WRSK. One method is referred to as the "conventional method" because it has been in use for so long. The other is called a "marginal analysis" computation (MA), so named because it builds a kit by evaluating the benefits gained per dollar cost and adding the items providing the most benefits. The MA kit concept first builds a conventional kit and then evaluates it in terms of two parameters, the expected number of stock due out (SDO), and the expected number of aircraft missing a WRSK item at some time during the WRSK support period (called expected number of not mission capable aircraft (NMC)). A marginal analysis kit is built using the

SDO and NMC of a conventional kit as goals, in an attempt to construct a new kit that offers the same level of performance at the same or lesser cost. An example of a MA WRSK is contained in Appendix C. BLSS assets are computed on a daily basis using a table which recognizes daily demands, assets coming out of base repair, and order and ship time pipelines. A BLSS example can be found in Appendix C.

Foreign Military Sales Requirements

Foreign military sales (FMS) involve the sale and transfer of major weapons systems, their support equipment, and the necessary training support to a foreign nation. There are three phases of FMS. They are: (1) The delivery of the weapons system package, (2) initial support, and (3) follow-on support.

The delivery of the weapons system package is the actual transfer of the end item to the purchasing country. End item production requirements are simply the number of components used in the end items delivered. The end item requirement is identified in the Letter of the Offer and Acceptance (LOA), and is based on what the purchasing country desires. AFSC is normally responsible for the delivery of new end items (37:4-17).

End items, such as the F-16 aircraft, must be supported upon delivery to the foreign country. Initial support is the means by which this end item support is accomplished. Initial support provides maintenance support for a given initial time period, usually one year. The initial support package is computed primarily on IM inputs, and uses the country's projected flying hour program, the ISSL, the Material Requirements List (MRL), and other supporting documents based on experience (45:21). The initial support

package will normally be in place either prior to, or at the time of the end item delivery.

Follow-on support for the F-16 is managed by AFLC, and picks up where initial support leaves off. There are three types of follow-on support: (1) The defined order case, (2) the blanket order case, and (3) the Cooperative Logistics Supply Support Arrangement (CLSSA). The defined order case is an order for specific spare parts placed by a foreign country against U.S. assets. Defined orders are filled from stock if there is a surplus in the Air Force supply system. Blanket Orders refer to a predetermined amount of money on deposit with the United States, against which charges are levied for spare part orders. Orders are filled from U.S. stocks if there is a surplus. For both the Defined Order and the Blanket Order, requisitions are backordered if supply levels are below minimum. For this reason, the CLSSA is the most attractive to foreign countries. Under this concept, foreign countries buy-in to the USAF supply system, contributing up-front money from which the Air Force procures spares in anticipation of the foreign country's demands. These spares are maintained within the USAF supply system, side by side with USAF assets. Member countries then requisition parts under the same priority system as the USAF. The ALC System Manager may recommend a specific level of inventory, using the MRL, the Provisioned Parts Breakdown, the D041 and the D062 computer systems, or the using country may specify what it wants on-hand (37:6-13). The H051 data system tracks the CLSSA transactions.

Testing Requirements

The requirement for testing the F-16, or any other major weapons system and their subassemblies, exists throughout the weapons system

acquisition process. Test requirements are broken down into two major categories, Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) (2:2-1). DT&E assists the design and development process by demonstrating that design risks are minimized, and verifying technical performance specifications and objectives. The implementing command (AFSC) manages the DT&E program, with Air Force Test and Evaluation Center (AFTEC) and MAJCOM support (2:2-2). AFTEC does not have the organic resources necessary to execute the tests. Because of this lack of testing capability, during the initial phases of the Weapons System Acquisition Process AFTEC will assign certain testing requirements to the appropriate command. Resource requirements are then satisfied by these responsible commands (44:3-1). The prime contractor, General Dynamics, will usually conduct the early DT&E, including the pre-production qualification tests (2:2-2).

OT&E is performed to estimate a system's operational effectiveness and suitability, identify modification requirements, and provide information on tactics, doctrine, and personnel requirements (48:3). AFTEC manages the OT&E program, which is subdivided into Initial Operational Test and Evaluation (IOT&E) and Follow-on Operational Test and Evaluation (FOT&E) (2:2-4 to 2-7). IOT&E is accomplished prior to the Full Scale Production Decision. FOT&E is accomplished after the Full Scale Production Decision by the MAJCOM (43). The contractor provides spare support during the DT&E phase. During OT&E, AFLC will initially provision testing spares. Since the Air Forces recognizes that initially provisioned spares will not be immediately available, AFSC will negotiate for interim contractor support to cover a sufficient period of time until initially provisioned spares are available (21; 24).

Training

Throughout the life of the F-16, there will be a requirement for Air Force personnel to be trained on its operation and maintenance. This training is conducted primarily on its subassemblies and the aircraft itself. Because of the environment in which it is used, this training equipment experiences a higher failure rate and subsequent demand rate than the average F-16 (11:7). This means that a larger than average number of spares will be required to support training requirements. Additionally, the appropriate quantity of training equipment must be in place as early as possible to insure personnel are adequately trained in equipment use before being allowed hands-on contact with an operational F-16. For the above reasons, spare requirements for training are greater than normal end item requirements. "How much" higher is based on a best guess principle by the senior logistician from Headquarters, Air Training Command (ATC) (11:13). This best guess is a judgment call based on ATC's experience with similar equipment used in training programs. The higher requirements are identified during the provisioning process and are included in the ISSL. Once training operations are underway normal spare part replenishment is conducted under standard supply support arrangements outlined in AFM 67-1.

Retrofit

Retrofit is the process by which aircraft components are modified after the aircraft has entered the production phase. Component modification is normally the result of technological or design improvements to the original aircraft subsystems, and may require either exchanging an obsolete component with a new component, or merely modifying an existing component (The F-16 is currently in the Multi-Stage Improvement Program

(MSIP) which incorporates numerous technological and design improvements). When the decision is made to completely replace an aircraft component, the System Program Office (SPO) under AFSC will contract for enough replacement parts to fit the aircraft currently deployed, plus those on the assembly line, until production can catch up with the change. The SM in AFLC picks up this responsibility after the Program Management Responsibility Transfer (PMRT). Design improvements that require only a modification to existing equipment need a much smaller supply of retrofit spares. Interestingly enough, there is no quantitative procedure to determine the precise amount of spare assets needed to support the retrofit program (35). Instead, configuration management specialists use a "best guess" aproach to determine the appropriate number of retrofit spares. This level attempts to approximate the base or depot repair cycle quantity plus a safety level, depending on the echelon of repair.

In the event a weapons system is procured under the Reliability Improvement Warranty (RIW) concept, the manufacturer is responsible for providing modifications for the length of the RIW contract. At the time that the RIW contract expires, the manufacturer is held responsible for insuring that all modifications initiated up until that date are completed on all aircraft in the inventory. The Air Force will take retrofit responsibility after the RIW program has terminated (38).

Repair

Whenever an aircraft subassembly fails, it is either condemned or becomes a reparable asset. Reparable assets are repaired either by the Air Force, at an organic depot facility, or are contracted out to the vendor for repair. Normally, the vendor who produced the item will also be the vendor

who repairs it (24). Specific repair processes depend on the repair contract, and repair contracts will vary from vendor to vendor. Reparable assets returned to the F-16 prime contractor (General Dynamics) will be repaired if the repair cost is no greater than 75% of the asset production cost. If the repair cost exceeds 75% of the item value, the asset is condemned and a new asset is bought (24). Assets purchased under the RIW concept will be repaired by the vendor at no cost to the Air Force for the duration of the RIW period. For most other vendors, a "break-down and quote" contract is used until reliable repair cost standards for the parts are available. The vendor develops these repair cost standards by repairing a number of assets over time and using the experience to assign an average cost per repair action. Until these average costs are available, the vendor will charge the Air Force a fixed fee for tearing the asset down, and will then quote the Air Force a repair price. Air Force procuring activities will then determine whether the asset will be repaired or condemned. An important principle in the vendor repair cycle is the division of repair and production processes. This division occurs in one of three ways: (1) repair is accomplished simultaneously with production; that is, repair and production actions take place on the same line intermittently, (2) repair and production activities take place on the same line during different, distinct time shifts, or (3) repair and production activities are conducted on several different, physically separated lines (24; 25; 26; 27).

We have thus far identified ten major sources of demand for F-16 items (See Table 2-1).

Table 2-1

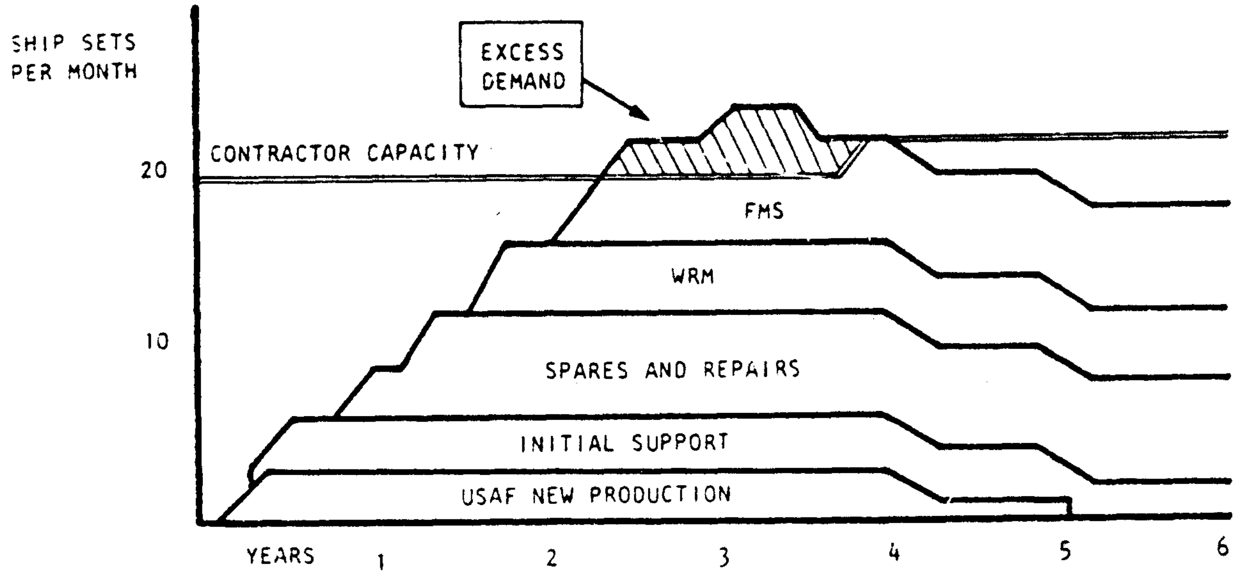
Summary of F-16 Requirement Generation Sources

Requirement	Responsible Command
Interim Contractor Support	AFSC
Initial Provisioning	AFLC
Initial Supply Support Lists	AFLC
Repair Cycle Requirements	AFLC
War Reserve Materiel	AFLC
Foreign Military Sales	AFSC/AFLC
Testing	AFSC/AFLC
Training	ATC
Retrofit	AFSC
Repair	AFLC

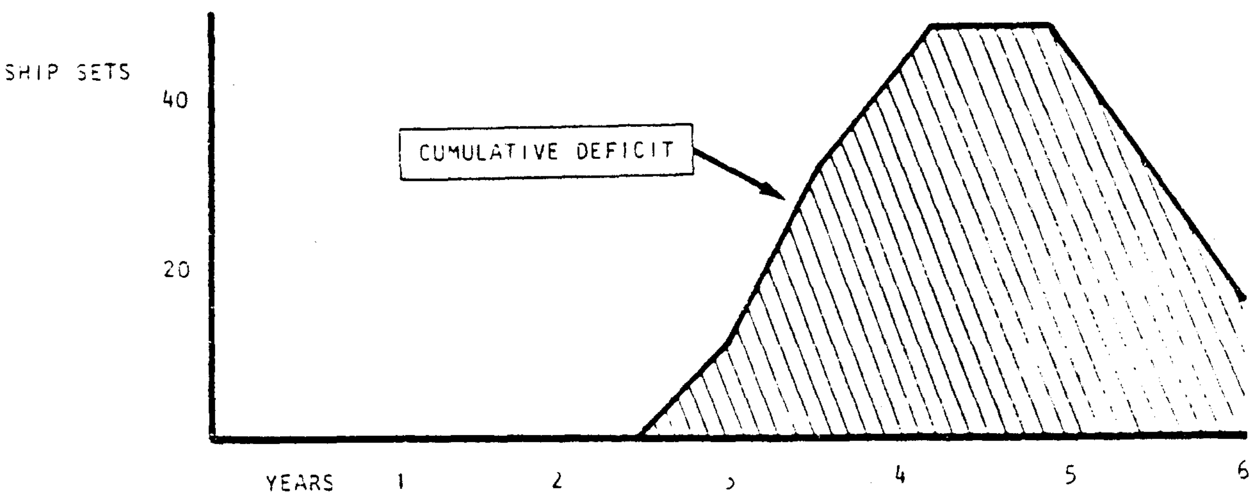
These sources are all a drain on the total available pool of F-16 assets. The contractor, however, does not have an accurate, consolidated requirement forecast of all these sources to help him in planning to provide for this pool. Rather than over-expand his facilities based on uncertain future requirements, the contractor will normally commit a modest amount of his resources on what he considers a "sure thing". It is only when the contractor becomes saturated with demands that he considers expanding his facilities. In some cases, especially with heavy industry, retooling and facility expansion may take 1-2 years. Figure 2-1 illustrates this dilemna. The upper graph shows a hypothetical contractor's repair and production capacity, 20 ship sets, compared to the requirements generated against him over a 6 year period. The requirements are layered to show their

Figure 2-1

Contractor Capacity Versus Demand



CONTRACTOR CAPACITY VERSUS DEMAND



ITEM DEFICIT

cumulative effort. By the 2nd year of production the contractor realizes that the combined production, spare, and repair requirements are exceeding his capacity. The contractor decides to expand capacity in year three, and that expansion is completed by year four. Between years two and four the excess demand on the contractor creates an item deficit, reflected on the lower graph. The deficit is cumulative, and if the Air Force possesses no organic repair capabilities, may linger on years after the capacity expansion is complete. How adversely the Air Force is impacted depends on how long the deficit is, and whether alternate sources of supply are available. This entire situation can be averted if the contractor receives accurate, consolidated demand forecasts early in his planning stage, but this is normally not possible.

By reviewing the major sources of demand we find that the accurate consolidation of demands from these sources is complicated by several factors. First, there is the inherent weakness in each source's method of requirement forecasting. Although some of the requirement sources, such as the ISSL, WRM, and repair cycle requirement use empirical techniques to derive their forecasts, all of the requirements are based to some degree on best guesses and estimates. It is extremely difficult to develop accurate forecasts when using guesses on the initial base. The second factor which impedes accurate requirements forecast consolidation is that the sources are individual offices belonging to three separate MAJCOMs. AFSC manages new production and retrofit requirements, Air Training Commands determines training requirements, and AFLC handles WRM and resupply. Although there is coordination between the commands for some requirements, such as provisioning, as a rule, requirements forecasts are conducted

separate of one another. A third factor that complicates accurate consolidation of requirements forecasts is the nature of the weapons system acquisition process.

The Weapons System Acquisition Process

The weapons system acquisition process is the four phase cycle by which a major weapon system is developed and employed by the Department of Defense. The four phases of the weapon system acquisition process are:

(1) Concept Evaluation

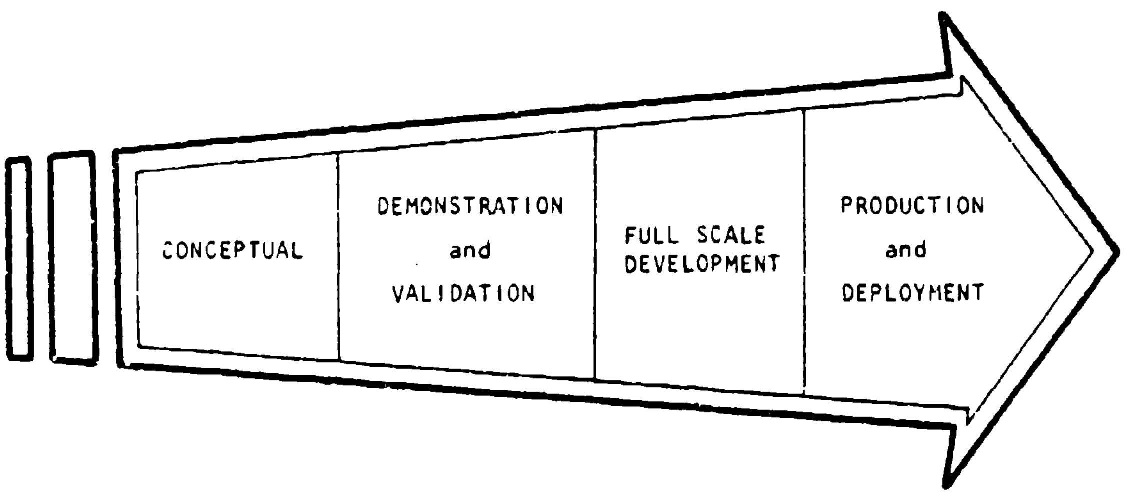
(2) Demonstration and Validation

(3) Full Scale Development

(4) Production and Deployment

Figure 2-2

The Weapon System Acquisition Process



During these four phases a large number of item requirements are generated, each of which must be satisfied by industry. During the Demonstration and Validation Phase there is some degree of uncertainty surrounding the technological parameters of the proposed weapons system. Because technology advances at a rapid pace in the aerospace industry, many aircraft items are subject to design changes to incorporate improved technology. Contractors must be prepared to fulfill all item demand requirements, but at the same time they realize that technological modifications may force them to substantially alter their production procedures. It is, therefore, difficult to provide contractors with long run, accurate forecasts that have any degree of reliability.

As the weapons system acquisition process enters the Full Scale Development and production phases, the risks gradually diminish and the aircraft design stabilizes. However, the number of demand requirements for aircraft items increases from just testing and ICS to all the major requirements identified thus far. Industry's frustration with technological uncertainty is replaced with the frustration of trying to satisfy multiple sourced, unconsolidated demand requirements for the same item. The environment in which this frustration develops is the defense market (34).

The Defense Market

Throughout the weapon system acquisition process the USAF interacts with the defense industry by negotiating numerous contracts for the individual line items used in the weapons system. This interaction takes place in the defense industry market, which differs in form from the traditional buyer-seller arena. Theorists label the defense market a bi-lateral monopoly, where a single buyer (monopsonist) meets a single seller (monopolist) (38).

Based on our literature review, we feel that the defense market cannot be clearly labeled as a bilateral monopoly, but rather, it varies according to the level of the DOD concerned. Categorizing the defense market as any single market type would be oversimplification. Closer observation of the defense market reveals a variety of market structures operating simultaneously, all dependent upon the level of the contract award and the contract's timing during the Weapons System Acquisition Process. In the early phases of the acquisition process, at the Service (AF, Army, Navy) level, the initial contract award places the manufacturer and DOD on essentially equal footing. Both sides possess respectable bargaining power, which normally results in a compromise of initial objectives. However, during the later phases of the acquisition process several agencies award contracts for the same item. In the Air Force, for example, AFSC may be contracting for line items to fill aircraft production demands, while AFLC will be contracting for the identical line item to fulfill supply requirements. Thus, two essentially independent command agencies contract for the same product, and quite possibly from a sole supplier. In this situation we encounter substantially different market stuctures than we did initially, to the detriment of the Air Force. What results is an environment where the seller is a monopolist and the Air Force buys as an oligopsonist. The monopsonist benefits of quantity buys are lost, yet the contractor retains the power of the monopolist.

This sole source dependence is compounded by substantial barriers which exist to firms entering the market. The unique nature of the defense business requires a degree of marketing specialization with which few firms are familiar (19:36, 46). The demand for high technology and superior

performance requires signficant engineering and scientific capability, specialized equipment, and large quantities of capital (19:47). Development for new systems requires from 7-10 years; production takes from 3-5 years (19:30). The cost of investments for research, capital equipment, and test facilities is beyond the capability of most firms. Federal regulations, "boilerplate clauses", such as Occupational Safety and Health, Equal Employment Opportunity, Small Business Administration, and Unemployment Area Assistance guidelines are rigidly enforced in government contracts (19:48). For many industries, the requirement to comply with these boilerplate clauses becomes cost prohibitive (38). Defense business often requires worker security clearances, which are expensive and time consuming (19:48). Between the years 1968 and 1975, the number of Air Force subcontractors fell from 6000 to under 4000, a reduction of over 35% (19:129). This alarming drop in grassroot production further restricts alternate sources of parts production. The government, therefore, becomes increasingly dependent on sole source suppliers. The suppliers, in turn, experience increasing problems in satisfying unconsolidated DOD requirements.

Summary

In Chapter 1 we hypothesized that the defense industry was experiencing frustration and turmoil over the non-consolidation of demand requirements by the various requirements sources within the Air Force.

We cited several studies to back up this hypothesis, and constructed a general research plan to further validate our claim. The literature review further substantiated our hypothesis by showing that F-16 demand requirements are generated by at least ten separate agencies within three Air

Force major commands. When these independent requirements are transmitted to industry, the contractors (41% of whom were sole source in FY81) may become saturated, and thus unable to meet all Air Force requirements. We content that when 41% of the Air Force's new contractors are sole source, and may be submitted to this unconsolidated demand process, the Air Force is nurturing a problem of considerable proportions.

To assess the magnitude of this problem we will conduct a field investigation of key levels in the requirements generation process.

CHAPTER III

FINDINGS AND DATA ANALYSIS

For our field investigation, twelve items were selected from a pool of 53 items presently investigated in an on-going Falcon MAP study (see Table 3-1). Project Falcon MAP is a USAF vendor saturation study further discussed in Chapter IV. Items were selected from a cross-section of aircraft components and include the secondary power system, hydraulics, instrumentation and fuel system. No attempt was made to pick items at random; rather, to facilitate interviews, items were selected on the basis of their location. It is specifically intended that no statistical inferences be drawn from the data received and analyzed.

Numerous interviews were conducted with both Air Force and manufacturing personnel. Air Force interviews were conducted with six item managers (three managers at both the Ogden ALC and the San Antonio ALC) representing twelve items. Additionally, interviews at the Ogden ALC were conducted with the Chief of the F-16 Production Management Branch, the F-16 Contract Maintenance Supervisor, an Inventory Management Specialist Supervisor, and a Supply Projects Officer heavily involved with Dyna METRICs application in a Readiness Initiative Group.

To receive the manufacturers view of the requirement generating/procurement process, key personnel at both the prime and subcontractor were either personally interviewed, or interviewed through the use of questionaires. To facilitate our data analysis and provide objective findings, personnel interviewed were those responsible for the same items as

the Air Force item managers. At the prime contractor, two General Dynamics procurement planning and control supervisors were personally interviewed. These individuals in turn had distributed Appendix F questionaires to the item planners for the twelve items studied. Their item planner's responses were then returned to us. At one subcontractor, two senior project managers were interviewed, one by phone, and the other by questionaire. At the remaining subcontractor all contact was completed by questionaire. At this subcontractor, responses were received from the department heads of the production planning, materials control, and main marketing divisions.

Interview responses have been summarized by question. Several item managers requested anonymity while answering questions. Since the thesis solicited frank responses, item managers will not be mentioned by name, but indirectly referred to by the national stock number (NSN) of the item under investigation.

TABLE 3-1

Item Nomenclature and NSN

Gas Turbine Power Unit	2835-01-116-0006
Jet Fuel Starter	2835-01-073-4195
Fuel Flow Proportioner	2915-01-041-4481
Fuel Strainer Assembly	2915-01-083-0431
Refuel Shutoff Valve	2995-01-060-8514
Emergency Power Unit Regulator Valve	4810-01-071-4753
Central Interface Unit	1280-01-109-6916
Rudder Integrated Servo-Actuator	1680-01-106-1594
Horizontal Stabilizer Integrated Servo-Actuator	1680-01-105-7111
Main Landing Gear Wheel Assembly	1630-01-038-9239
Brake Control Box	1630-01-038-8282
Anti-Skid Control Box	1630-01-082-4733

Questions were designed to solicit the personal opinions of the individuals concerning the item procurement process. Item manager questions were intended to reflect the Air Force viewpoint, and centered on questions relating to: who generates the various requirements; are forecasts consolidated; how accurate are they; and common and significant problems with the process. Prime and subcontractor questions were similar in content, but geared towards the receipt of orders, frequency of order arrival, order accuracy, and problems encountered during production. As a whole, it is intended that the questions represent a well-rounded picture of the requirements generating process, and the manufacturers' response to satisfy those requirements.

<u>Item Manager Question Responses</u>

Question 1. Do you attempt to consolidate investment item requirements that are generated by the various demand sources?

Each independent asset requirement (WRSK, BLSS, etc) is combined into a single consolidated requirement. The mechanism for this consolidation is the D041 computer system. Major Commands input their flying hour projections for five years into the D041. Using supply information provided by each Air Force bases' UNIVAC 1050 II computer system, the D041 extracts the number of recorded item failures to date. These failure rates are applied to the total flying hours flown to date to obtain a historical failure per flying hour rate. This failure rate is then applied to the quarterly flying hour projections to obtain an estimated number of item failures per future quarter. The item's NRTS condemnation rate is subtracted from the projected number of item failures to generate an item-buy recommendation. Any remaining failures are coded as repairs.

Provisioning and WRM requirements are loaded into the D041 system from other automated systems. All other sources of requirements (ISSL, FMS, Testing, Training, Retrofit and non-programmed requirements), known collectively as "additives", are manually input into the D041 by each item manager (25; 26; 27).

Question 2. Is the final usage of each item identified to you when the requirement order is placed?

Yes. Replenishment cycle spares are computed by the D041 computer system. Additive requirements are submitted by letter to the item manager by the additive's OPR. These additives include the ISSL, FMS, Testing, Training, Retrofit, and non-programmed requirements (25; 26; 27; 30). Non-programmed examples may be emergency FMS spares requests, or other U.S. services' requests for common assets, such as C-130 aircraft parts. WRM requirements are fed into the D041 system via the D032 system, and identified on the D041 computer printout as such (28).

Question 3. Do you feel the Air Force generates relatively accurate asset requirement forecasts?

Almost all the Air Force personnel interviewed felt that the Air Force provides a fairly accurate requirements forecast (25; 26; 27; 28; 30; 41). As a rule, there was solid support for the D041 system. It was felt that the shortcomings in the D041 system were attributable to items undergoing engineering design changes, incorrect maintenance factors, and flying hour program changes entered into the system (25; 26; 27; 28; 29; 30). Item managers stated that as long as reliable information was input into the D041 system, and as long as funding was available to complete all recommended

buys, accurate repair and buy actions would be forecast. One area of questionable validity, though, was the D041's "Total Available Depot Repair" figure, which is computed on items even if no organic repair capability exists (31). If a vendor fails to deliver a contracted repair action within the D041 repair parameters, that "Depot Available Asset" does not, in fact, exist. This void, however, is not carried forward as a buy action for several quarters, which creates a backorder condition that takes several more quarters to rectify (28; 31).

Question 4. Do you experience problems with contractors failing to provide spare and repair assets on time?

Item managers unanimously agreed that contractors were very reliable in providing spare assets on time, and that they rarely experienced delays. Delays that did occur were generally attributed to labor strikes, extended materiel procurement lead times, and sub-tier vendor problems (problems which were beyond the direct control of the vendor) (25; 26; 27; 28; 29; 30).

Item managers did, however, experience problems with the delivery of repair assets (25; 26; 27; 28; 29; 30). Several repair assets were identified as typically taking 6-12 months to complete the repair cycle to serviceable status (29). This excessive repair time was attributed by item managers to "Tear-Down and Quote " repair contracts, and to vendors using a single manufacturing line or facility to produce new aircraft production assets and conduct repair actions.

Question 5. Do you experience problems with establishing distribution priorities once you receive items? How do you rectify these problems?

Yes. Whenever the number of assets available for issue is less than the number of assets demanded, the item manager must determine where those items will go. Under normal conditions, assets are released as orders from the bases arrive, with the highest priorities filled first (25; 26; 27; 28; 29; 30). Whenever an item manager deems that an item deserves special attention, a Manager Review Code is assigned to the item. Under this circumstance, the item manager is notified of all serviceable asset arrivals at the depot. The item manager then distributes the assets according to the highest priorities and in the most equitable manner (25; 26; 27; 28; 29; 30). For example, should a number of MICAP[4] conditions exist in the Air Force, the item manager will spread the assets across the entire Air Force, rather than concentrate on any one base, regardless of backorder dates. The item managers felt this more of a judgment call than anything else, influenced by: world wide fleet operational readiness rates; bases in potential conflict area; inputs from the System Manager; and requests by the TAC Logistics Officers.

Question 6. Would a consolidated demand forecast (not a contract commitment) be helpful to you? Why/Why not?

Item managers already have a consolidated demand forecast in the form of the D041 computer product. The D041 consolidated forecast gives recommended repair and buy actions several years into the future (25; 26; 27; 31).

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[4]See Glossary.

Question 7. If there was one improvement you could make in the item procurement process, what would it be?

Item managers expressed displeasure with the "Assets Available from Depot Repair" figure (found on D041 computer product) of items for which no organic repair capability exists (28;31). These depot repair assets are items that are contracted out for vendor repair and are subject to substantial fluctuations in repair cycle time. Any items that are programmed for repair during a given quarter, but are not released from the factory as scheduled, result in not only a back order condition, but also a MICAP condition. Regarding this situation, item managers feel they should be given more room for judgment calls to head off potentially high MICAP conditions. Other responses suggested that measures be taken to require sole-source contractors to provide separate production and repair facilities. Also mentioned is a change to the present administrative channels in the procurement process, primarily because of the excessive delays some purchasers encounter. As an example, the procurement of a secondary power system item, whose purchase package price exceeded $100,000, had to be reviewed by and approved at 10 different supervisory levels, taking about 30 days. Records showed that requisition actions on this particular component, on the average, took 12 months from the time the item manager initiated paperwork until the purchase request was completely processed (30). In view of delays of this length, it was felt that fewer supervisory approvals would lessen the procurement time. The last recommendation was that full funding be provided for item purchases. At the present time, item procurement actions that total over $100,000 can only be funded 60% (28; 29; 30).

Prime Contractor and Subcontractor Question Responses

Question 1. Who are your customers?

The United States Air Force is General Dynamics' Fort Worth Division prime customer. General Dynamics (GD) receives production requirements from ASD at Wright-Patterson AFB, OH, and support requirements from Ogden Air Logistics Center at Hill AFB, UT. Foreign military sales orders are processed and received through appropriate Air Force channels. Subcontractors typically sell to all the Services (Army, Navy and Air Force), Defense Supply Centers, other F-16 subcontractors, and ur e-lated commercial customers (23).

Question 2. What is the frequency that you receive parts orders?

In the past, General Dynamics has received new production orders annually. General Dynamics is currently under a multi-year USAF commitment through FY85, which holds firm the number of aircraft to be purchased. Support orders are received with varying frequency from 1 to 15 per month. Urgent (MICAP) support orders are filled from production assets, with payback from an existing spares order, or lead time away for a new replacement order (24). Subcontractors receive orders from the Air Force on a daily basis (23).

Question 3a. What are typical representative delivery rates requested on these orders?

General Dynamics stated that the production delivery rate is approximately 20 ship sets per month. Repairs and modifications range from an additional 1 to 30 ship sets per month (24). Subcontractors, however, felt there were no typical or representative delivery rates (23).

Question 3b. How does this compare with production rate capacity?

Delivery rates at the prime contractor level were all within the production rate capacity (24). Rates at the subcontractor level, however, were not. Subcontractors complained that required rates of delivery were generally at a rate earlier and greater than their production capacity could achieve (23).

Question 4. Do you feel the Air Force generates relatively accurate asset requirement forecasts?

General Dynamics stated that the Air Force did not generate relatively accurate forecasts. Firm production orders were often placed too late to meet General Dynamics schedule for lead-time-away material procurements. General Dynamics also receives continuous orders for spare asset requirements, rather than on an annual or multi-year basis. It was stated that if the Air Force had consolidated repair requirements into an annual buy, or provided multi-year funding, they would have realized a substantial cost reduction. General Dynamics also mentioned that retrofit requirements were normally presented to them too late to meet schedule requirements (24).

Question 5. Do you generate independent internal demand forecasts? If so, what factors do you use, and how do your forecasts compare to the Air Force? How do you reconcile differences?

Yes, General Dynamics does generate internal demand forecasts. These forecasts assume "worst case" situations for supportability. General Dynamics then adds an additional 20% to their projected support requirements as insurance against anticipated, but unscheduled, AFLC orders.

Internal forecast discrepancies are resolved by rescheduling and/or restricting production runs.

In the past General Dynamics has kept a 30 day inventory stockpile as a cushion for fluctuating demand requirements. However, because of high interest and inflation rates, General Dynamics is now pursuing a "zero bank" inventory policy, and plans to eliminate this cushion by mid-1983.

Question 6. Have you ever experienced problems with delivery priorities? How do you resolve these conflicts?

One source of delivery priorities for General Dynamics has been the Defense Priority System. Delivery problems have resulted because subcontractors have, at times, been required to manufacture assets for other prime contractors because of higher defense priority ratings. Another source of conflict has been competition for a subcontractor's production output. In this situation, both the Air Force and General Dynamics have separate contracts with the same manufacturer for a particular asset. If production rates are less than demands, asset output must be portioned out, with either General Dynamics or the Air Force receiving less than ordered (24). One subcontractor stated that when such a situation arose, the first order received had priority (23).

Question 7. Would a consolidated requirements forecast (not a contractual commitment) be helpful to you? Why/Why not?

General Dynamics response was that a consolidated requirement forecast would be very beneficial for planning purposes, allowing production scheduling to be accomplished within their production rate capacity, or at minimum, provide advance warning of potential rate capacity problems.

General Dynamics also felt that a consolidated requirement forecast would allow both General Dynamics and the Air Force to realize substantial cost savings because of large economic quantity purchases. However, one subcontractor stated that consolidated forecasts would be of little benefit (23).

Question 8. If there were one aspect of the parts ordering process that you could change, what would it be?

Overall, General Dynamics felt that an advanced, consolidated planning and funding process would be of the greatest benefit to them. They reiterated that consolidated planning and funding for spares would have resulted in both General Dynamics and the Air Force realizing the economic benefits of cooperative planning (24). Subcontractors felt that the long length of time that passes between a quote and the contract award should be shortened. The long delay adversely impacts the subcontractor, for whom changing prices and manufacturing capacity are critically important (23).

Response Analysis

The questions posed to item managers, prime contractor and the subcontractors revolved around five broad areas of concern. These areas are: the extent of consolidated Air Force requirement forecasts; the accuracy of those forecasts; the frequency of order placements; problems with the present procurement process; and recommended improvements for a more efficient procurement system.

Air Force Logistics Command does consolidate all of its interval requirement forecasts. This is accomplished by the D041 computer system, and the manual adjustments added by each item manager. The end product

is a quarterly buy and repair recommendation that should satisfy all of AFLC's asset requirements. Consolidation of requirement forecasts for Aeronautical Systems Division posed little problem, as it only encompassed new production and retrofit orders which were transmitted to General Dynamics.

Closely associated with the issue of consolidated forecasts is the accuracy of Air Force forecasts. Conflicting views on this issue were noted between Air Force item managers and manufacturing personnel. Item managers felt that D041 consolidated forecasts were accurate, while General Dynamics personnel refuted this claim with several examples of poor forecasting results. After examining both sides of the issue, we have concluded that the D041 computer system is a reliable forecasting tool, provided that: first, accurate background is entered into D041 computations, and second, sufficient funding is available to complete recommended buys. We assert this latter qualification for two reasons. First, present Air Force funding policies limit purchases over $100,000 to only 60% of the recommended dollar value (25; 26; 27; 28; 29; 30). This policy hampers the Air Force's ability to replenish aircraft and spare asset losses due to politically motivated FMS programs. Second, D041 forecasts are degraded by the legislative process of the US Congress and Senate. Many times, less than requested funds are appropriated, or actual appropriations are delayed. Thus, the lack of sufficient, timely funding for assets, by either the Air Force or Congress, ultimately reflects as inaccurate Air Force forecasts. Insufficient funding also creates an air of uncertaintly for manufacturers who are attempting to efficiently schedule production runs. Congressional funding delays essentially reduce a manufacturer's lead time for purchasing

raw materials or components to near zero. This, in effect, totally negates the efforts of Air Force planners and requirement forecasts.

It was also found that manufacturers received orders on a fairly frequent basis. The recommended buy order from the D041 computer program is generated each quarter. Yet, General Dynamics and subcontractors receive MICAP priority orders up to 30 times a month (24). In either situation, frequent orders of different quantities seriously hamper the manufacturers' ability to schedule production runs. Additionally, added costs are incurred because vendors are not able to pass on quantity discounts.

Problems in the present procurement system are numerous, some have been mentioned previously. The lack of sufficient funding is perhaps the most significant problem encounted. Also noted was the excessive supervisory approval necessary to complete large dollar procurement actions. This approval sequence can take as long as 30 days to complete (28). Another significant problem mentioned was the slow delivery of repaired assets from certain vendors. Missed delivery dates of repaired assets creates voids within the supply pipeline that are both time consuming and expensive to correct. Repair problems were common to both the Air Force and General Dynamics.

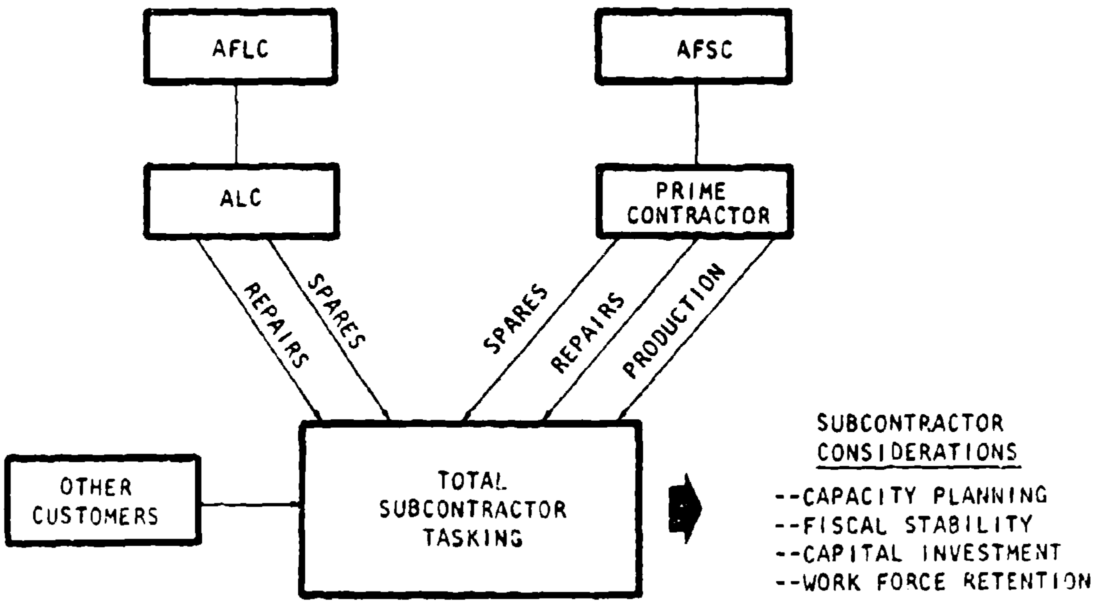
The recommended changes cited as the most beneficial to either the Air Force or the manufacturers are the use of a consolidated requirements forecast, and the use of multi-year funding. Item managers suggested streamlining the approval sequence for purchases, and the importance and necessity of full funding for procurement actions.

Findings

The first finding which surfaced during the interviews at Ogden ALC was that our hypothesis was, in part, misdirected. Nonconsolidation is not a problem between the separate requirements generating offices within AFLC as proposed; rather, the lack of requirements consolidation exists between AFLC and ASD. This lack of consolidation results in competition between the two commands for vendor capacity to fill new production, spare, and repair asset requirements. AFLC contracts for spare and repair requirements, while ASD contracts through the prime contractor for new production and retrofit requirements (see Figure 3-1). Vendor capacity is limited, and may be shared by other customers. Therefore, while requirements at the individual command or prime contractor level may appear to be within the vendor's rate capacity, the vendor is, in fact, inundated.

Figure 3-1

The Requirements Flow



The competitive nature that results during this situation causes conflicts regarding the final use of an asset; whether it will go to new aircraft production, or into the Air Force logistics pool.

Three other significant findings emerged from our investigation which are central to this issue, and therefore, must be addressed. These issues are: 1) Collective planning, 2) Vendor saturation and rate capacity expansion, and 3) Vendor delays on repair actions.

Collective Planning. This was a major theme that surfaced during the research. Under this planning concept, the Air Force would consolidate all requirements into a single, annual purchase. This one time, annual buy would generate significant savings in both monetary terms and delivery times. These savings would be even more substantial if both the Air Force and General Dynamics orders for a particular asset were consolidated and presented to industry as a single package. Table 3-2 shows an example of potential quantity-buy adjustments for F-16 avionics. Note that at smaller quantities, such as 20-50 ship sets, the quoted package price is 38.1% greater than if a quantity of 120-199 ship sets were purchased. At the other extreme, a single purchase of 800 or more ship sets would result in a 40% savings over the 120-199 base package price. The percentage figures presented below were computed for a relatively low dollar-value avionics component. Higher valued avionics components would realize a smaller percentage adjustment per given quantity, but because the components are higher priced, the actual dollar savings for either component type would be similar.

TABLE 3-2*

Quantity Buy Price Adjustments

Package Size (Ship Sets)	Change to Base Price (+ = increase in base price)
20 - 50	+38.1%
51 - 69	+28.7%
70 - 89	+19.4%
90 - 119	+5.9%
120 - 199	No Change to Base Price
200 - 249	-6.7%
250 - 319	-14.6%
320 - 399	-19.1%
400 - 599	-24.2%
800+	-40.0%

For the FY83-FY88 period the USAF is pianning approximately thirteen separate aircraft buys, two for USAF and the other eleven for FMS. Table 3-3 shows the changes to base price (Table 3-2) that would be applied to each buy if conducted separately, as compared to a single package buy.

TABLE 3-3*

Quantity Buy Adjustments for Specific Planned Buys

STANDING ALONE:	
USAF FY83-85	300 ship sets @ -14.6%
Alpha[5]	40 ship sets @ + 38.1%
AS A PACKAGE BUY:	340 ship sets @ -19.1%

*Example of a General Dynamics F-16 Economic Procurement Plan, General Dynamics For Worth Division, Dept. 084, 29 April 1982.

STANDING ALONE:

Israel	56 of 75 planned ship sets @ +19.4
Beta [5]	24 of 96 planned ship sets @ +5.9
Korea	16 of 36 planned ship sets @ + 38.1
Pi [5]	24 of 60 planned ship sets @ +28.7
Otto [5]	24 of 145 planned ship sets @ Base

AS A PACKAGE BUY: 144 ship sets @ Base Price

STANDING ALONE:

USAF FY86-86	303 ship sets @ -14.6%
Israel	19 of 75 planned ship sets @ +19.4%
Beta [5]	72 of 96 planned ship sets @ + 5.9%
Korea	20 of 36 planned ship sets @ +38.1%
Pi [5]	36 of 60 planned ship sets @ +28.7
Otto [5]	81 of 146 planned ship sets @ Base

AS A PACKAGE BUY: 530 ship sets @ -24.2%

These figures show a substantial reduction in total procurement costs for production items purchased using the cooperative planning concept.

The key to cooperative planning is the use of multi-year funding by the Air Force. This plan was viewed by both item managers and General Dynamics personnel as essential if production stability is to be attained (24; 41).

[5] Code names for country sales not yet consumated.

Vendor Saturation and Rate Capacity Expansion. Air Force item managers and contractor personnel have experienced essentially identical problems with vendor saturation. Saturation exists when the vendor is overloaded with work, and is no longer capable of fulfilling all production, spares, and repair orders.

Insufficient production capacity has a number of adverse effects, each of which can seriously impact Air Force operations. First, production of new aircraft can be interrupted due to the lack of assets. Second, the increased repair cycle time will create a void in the logistics supply line. Third, vendors may not be capable of accomplishing modification programs because their facilities are dedicated to other production requirements. Fourth, vendors may be incapable of responding to a sudden increase in spare or repair requirements. Finally, vendors may be forced into making priority decisions that do not reflect Air Force or prime contractor priorities. In summary, vendor saturation results in increased waiting times, and a growth in asset and raw material lead times (16).

From our research, it appears that vendor saturation is a problem limited to items for which the Air Force does not presently have the necessary depot facilities to conduct testing and repair actions (this capability is referred to as organic repair). From interviews, it was also found that saturation is more prevalent among vendors who do not possess, or conduct, separate production and repair lines. Item managers stated that vendors very seldom failed to meet production goals, whereas, on-time delivery of repaired assets was a continual problem (24; 25; 26; 27; 28; 29; 30; 41). At manufacturing facilities where production and repair lines coexist, repair actions were thought to rate second to new production, and

as such, are not completed until production goals are met. This was believed to be partially true because new production contracts were generally of a higher dollar value than those for repair actions. Thus, aircraft continue to come off the production line on schedule (in the F-16 actually ahead of schedule), even though repair support for those aircraft is severely limited.

During the 21 June 1982 F-16 stand-up briefing at Ogden Air Logistics Center it was reported that several critical subassemblies had 20-30 MICAPs each, and that there were appoximately 325 MICAPs fleet-wide. The vast majority of these MICAPs were directly attributed to vendors failing to meet repair commitments on time. This is an abnormally high MICAP situation, especially when considering the relatively small F-16 fleet size. The rate is particularly alarming in view of the planned growth of the F-16 fleet size (41).

Vendor Delays on Repair Actions. Through interviews we have isolated several reasons for vendor delays on repair actions. The first cause is a sudden surge in repair requirements. A repair surge normally occurs when a component design deficiency is identified, and, because of its severity, an entire fleet inspection Time Compliance Technical Order (TCTO) is ordered. Should the TCTO isolate 100 defective units, the 100 units are removed and returned to the vendor for repair. If the vendor's repair rate capacity had been 25 units per month, the vendor is now 4 months behind. It may then take as long as a year for the vendor to catch up with his total repair requirements. Another reason for repair surges is inaccurately forecasted failure rates. The logistics support for a new aircraft is based upon an engineered, or best-guess estimate of its individual

component's failure rates. If during system testing, or during its operational use, actual failure rates are found to exceed projected failure rates, then more spare assets will be required to fill the supply pipeline. Vendors will then be faced with repair requirements greatly exceeding that which had been originally anticipated.

A second cause of vendor repair lag is work priorities. Priorities can be dictated externally by the Defense Priority System, and/or internally by the company's management. Priorities established by the Defense Priority System must be adhered to by the vendor, and therefore, cannot be changed (38). Priorities established by management are somewhat more flexible, but they will almost always respond to the profit motive (24; 41). Additionally, the main emphasis of any manufacturing firm is on sales and marketing (41). As such, repair activities are deferred if a conflict arises between production and repair requirements.

A third reason that vendors lag on repair actions is the present Air Force system of contracting for repair of new items. Many of these contracts are of the "tear-down and quote" type which may also state that they are non-interference contracts. This means that repair contracts will not affect new asset productions (24; 29; 41). Under this type of contract, failed items are returned by the Air Force to the vendor for repair. When the item is received, the vendor will disassemble it and determine what type of repair is necessary. The vendor then submits his repair estimate to the Air Force, where the decision is made to either repair or condemn the item. It will often take up to six months from when an item is returned to the vendor for repair until repair or condemnation is authorized (29). There is, then, little incentive for the vendor to expedite repair actions.

We have identified three main reasons behind vendor lags in accomplishing repair actions. The projected 5-fold increased in the F-16 fleet size over the next 8 years suggests that incidents of repair lag and contractor saturation may increase dramatically unless some contractor effort is expended toward increasing repair rate capacity. Tables 3-4 and 3-5 summarize the Air Force and General Dynamics spare, repair, and new production requirements of two vendors examined in this study (16).

In both cases the consolidated requirements of the Air Force and General Dynamics are compared against the manufacturer's present rate capacity. The demand levels are under a "best condition" situation, where repair, spare, and production orders are stable, and at Air Force and General Dynamics minimum projected levels. Even under these favorable conditions, Industry A will experience saturation and subsequent backlog in June of 1985, and Industry B in June of 1982 (17). In actuality, Industry B is already two years behind in meeting repair requirements (18; 24; 41). One of the subcontractors interviewed acknowledged that this situation already exists at that company (23). An example of this situation was presented in Figure 2-1.

Corrective Actions Underway

One program currently underway that is examining the problems of vendor saturation and collective planning is Project Falcon MAP. Project Falcon MAP is an USAF sponsored vendor saturation study designed to determine the degree of present and potential vendor saturation and to recommend actions to contractors to assure adequate industrial responsiveness in the future (16). To facilitate their rate capacity planning study, Project Falcon MAP has employed the Rand Dyna-METRIC computer model

TABLE 3-4

Industry "A" Requirement Projections

For Hydraulic Device 1680-01-048-8977

Requirements	Calendar Year 82II	82III	82IV	83I	83II	83III	83IV	84I	84II	84III	84IV	85I	85II	85III	85IV	86I
Current Capacity	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Firm GD Production Spares and Repairs	30	30	39	43	31	33	38	32	27	24	28	28	23	21	21	18
Firm USAF Spares and Repairs	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Projected GD Production, Spares and Repairs	0	1	3	3	3	3	3	3	3	3	4	10	24	39	56	63
Projected USAF Spares and Repairs	3	1	3	4	6	8	10	11	12	12	12	12	12	11	14	13
CUMULATIVE DEFICIT	0	0	0	0	0	0	0	0	0	0	0	0	0	-2*	-18	-37

*A check of the math will show that 75-(21+39+11) = 4. A-2 value appears in the cumulative deficit block because the deficit first occurred in the last month of calendar year 85III. The surplus work capacity from the earlier two months in the quarter could not be applied to this deficit. A similar situation exists during calendar year 82III for Industry "B", shown in Table 3-5.

TABLE 3-5

Industry "B" Requirement Projections

For Hydraulic Device 1680-01-106-1594

and 1680-01-105-7111

Requirements	Calendar Year 82II	82III	82IV	83I	83II	83III	83IV	84I	84II	84III	84IV	85I	85II	85III	85IV	86I
Current Capacity	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Firm GD Production Spares and Repairs	51	60	56	52	43	58	61	44	31	31	31	33	31	26	18	26
Firm USAF Spares and Repairs	0	6	16	14	11	7	4	7	15	7	0	11	9	7	0	0
Projected GD Production, Spares and Repairs	0	0	2	6	6	6	6	6	6	6	8	11	27	60	60	60
Projected USAF Spares and Repairs	36	22	23	27	30	33	36	39	42	43	45	49	51	54	60	69
CUMULATIVE DEFICIT	0	0	-13*	-37	-52	-81	-113	-134	-153	-165	-174	-203	-246	-322	-385	-465

*See Footnote for Table 3-4.

to forecast F-16 requirements. This model differs from the backorder levels computed by D041 by forecasting item buy and repair actions based on a target NMCS[6] rate. Dyna-METRIC incorporates several dynamic factors in forecasting requirements that D041 ignores. For example, Dyna-METRIC considers exercise flying hour surges, the impact of increased foreign military sales of weapons, and rapidly changing war-time requirements. Each of these factors contributes to the increased demand for spares, and repair assets. It is because of this ability to insert changing variables that Dyna-METRIC can aid in rate capacity assessment. Given a fleet size and flying hour program, it can project the total assets required for a peace-time or war-time scenario. This forecasted requirement for the asset can then be compared to existing or planned rate capacities to identify potential shortfalls (32; 40).

[6]See Glossary.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This investigation began with a comprehensive literature review which identified and described the numerous Air Force requirements for new production, spare, and repair assets. Responsibility for the procurement of these assets is divided between AFLC, which manages spare and repair assets, and ASD, responsible for new production and retrofit requirements.

The investigation continued with an examination of the present procurement process, taken from both the Air Force viewpoint and the contractor viewpoint. The ALC item manager interviews revealed consolidation of all AFLC generated requirement forecasts. This consolidation was computed on a quarterly basis through the use of the D041 computer system. The consolidated requirements figure from the D041 was then used as the quantity buy figure. Item managers stated that given correct factors, minimal clerical errors, and the necessary funds to complete buy quantities, D041 consolidated forecasts were accurate. These same item managers attributed shortages of assets primarily to the inability of vendors to repair assets on time.

Item managers also thought that repair lags were limited to sole-source vendors, or vendors who had a single production facility in which new production and repair actions took place. When total production requirements exceeded capacity, vendors filled new spares orders at the expense of repair actions.

Vendors revealed a more negative viewpoint of the present Air Force procurement process. General Dynamics felt that the Air Force did a poor job of forecasting requirements. Often, production orders for some assets were placed with desired delivery dates that could not be met because of long lead times for raw materials or subassemblies. This, in turn, leads to MICAP conditions within the Air Force. In the past, and until mid-1983, the Air Force has been able to satisfy many MICAPs by purchasing assets from General Dynamics' inventories. However, under the new General Dynamics' zero-bank inventory policy, General Dynamics will not have sufficient inventories to meet all emergency MICAP requests (24). General Dynamics also noted that the Air Force placed frequent orders, of varying sizes, and at random intervals, rather than on an annual basis. As a result manufacturers are not able to pass on monetary saving associated with large production orders.

General Dynamics is faced with the same production problems that confront the Air Force. These problems stem from two sources. The first is the Defense Priority System, which establishes production priorities of defense related products within a company. The second is the competition for a vendors' production facilities; if insufficient production capacity exists, vendors prioritize production orders.

The greatest unknown faced by vendors and subcontractors is the total demand for a particular item. It appears that the independent nature of the AFLC and ASD/General Dynamics procurement process places the greatest burden on production activities. Falcon MAP requirements forecasts not only provide the "first" consolidated forecast for assets a contractor sees, but can also be used as a means of comparing a vendors'

stated production capacity with anticipated requirements. This should provide both the Air Force and General Dynamics with some degree of advanced warning of potential asset shortages. Falcon MAP forecasts can also be used by vendors to base the construction of expanded production facilities on.

As an aid to matching rate capacity with production requirements, Dyna-METRIC holds enormous potential. Used as an analytical tool, it can compute asset requirements given an increase or decrease in a number of variables to include war-time scenarios or foreign military sales. Asset requirements computed from this model can then be used to compare future requirements against expected production capacity. Again, insufficient production capacity can be identified, allowing adequate time to initiate corrective actions.

We conclude that our hypotheses, the lack of consolidated requirement forecasts by the Air Force has an adverse impact on contractor production activities, is misdirected. Air Force Logistics Command does consolidate its internally derived requirements through the D041 computer system, and the manual adjustments added by item managers. The lack of consolidation exists between AFLC and ASD. Both commands, which purchase assets for spare and repair actions, and new aircraft production and retrofit respectively, do so independent of one another. As much, vendors received independently derived orders that are placed on a piece-meal basis, with no long-term forecast on which to base production runs.

Several other factors arose which were found to prolong, or adversely impact, the present procurement process. One factor is the inordinate

number of supervisory approvals for large dollar procurement actions. It may take up to 10 approving officials and 30 days to complete initial purchase requests. Another factor is the use of the "tear-down and quote" method of repair, which can take up to six months to complete. The last factor is the lack of appropriated funding necessary to purchase adequate spare and repair assets. The combined influences of each of these factors has a detrimental effect on procurement activities.

The effects of contractor saturation, caused largely by the lack of consolidated purchase requirements, are serious and numerous. These effects include increased waiting line and lead times, increased repair cycle times, the inability to support production requirements, and the inability to satisfy modification requirements. A separate consequence of unconsolidated requirements is the inability of contractors to purchase material in economic quantities and the loss of potential dollar savings by the Air Force in program cost.

The problem of vendor saturation and its associated effects will continue to grow for a variety of reasons. One reason is the increasingly sophisticated nature of today's weapon systems, and the shrinking number of manufacturing firms with the facilities and capital base to support production. Another reason is the potentially large number of weapons the industrial base is required to support. Where present attention has been paid to the effective marketing of a system, the future will concern itself more with the ability to support a system.

Recommendations

To ensure the long-term ability to meet new production, spare, and repair asset requirements for any weapon system, the following recommendations are put forth.

Recommendation No. 1. Continuation of multi-year funding for F-16 procurements, and the expanded use of this funding concept to other acquisition programs.

The F-16 was the first USAF program to be provided with multi-year funding. This long-term funding has afforded contractors a high degree of production planning stability that is vitally needed. With these dedicated funds, contractors are able to purchase raw materials and subassemblies in large quantities, efficiently and effectively schedule production runs, and adequately plan for future expansion of production facilities if needed. Perhaps most importantly, this funding allows for the procurement of long lead time materials. These and other benefits would be realized in contrast to the numerous uncertainties and delays associated with annual appropriations. Air Force benefits from multi-year funding include monetary savings from large quantity buys, production stability, and a more stable logistics pool.

Recommendation No. 2. Adoption of multi-year funding concept to the purchase of Air Force spare and repair assets.

Benefits cited in Recommendation No. 1.

Recommendation No. 3. Coordination of Prime Contractor and USAF acquisitions of new production, spare, and repair assets.

The realization of benefits from this action include monetary savings, and the procurement of lead time sensitive materials. Other benefits include those cited in Recommendation No. 1.

Recommendation No. 4. Continuation of Cooperative Planning studies and the expanded use of this planning concept to other acquisition programs.

The key to high operational readiness rates is the ability of industry to meet the needs of new production, spare and repair requirements. The concept behind Falcon MAP concerns itself with matching stated vendor production capacity against projected demands. Early identification of insufficient capacity will allow corrective measures to be initiated before serious asset shortages exist. With the use of long-term asset requirements forecasts, vendors will realize the market potential for an item, and have adequate time for facility expansion if needed. Serious production deficiencies may also signal a need for multi-source manufacturers.

Recommendation No. 5. Initiate research studies concerning the significant problem of excessive repair cycle times for assets.

Excessive repair cycle times not only adversely effect operational readiness rates, but also require large pipeline quantities to allow for longer repair times. Further research should concentrate on:

1) The requirement for sole-source contractors to provide separate repair and new asset production facilities.
2) The need and value of:
    a) separate repair receiving area,
    b) separate "tear-down and quote" area,

c) separate repair facility,

d) separate shipping facility.

3) A complete review of present Air Force "tear-down and quote" policies.

   a) An alternative is the establishment of a fixed wear rate. For example, if the repair cost is more than 75% of the original cost of the asset, then it would be condemned and replaced.

4) Alternatives to the present policy of repair under contract.

GLOSSARY

a. Average percent of Base Repair (PBR). The Average percent of Base Repair is the repair rate for the current and past four quarters. The repair cycle records for an item contains the number of units repaired, the number NRTS and the number condemned. The average percent of base repair is computed internally from the data for the current and past four quarters showing the number of units repaired, NRTS, and condemned. Master items show the PBR for the entire group, and others show the PBR of the individual item.

Formula: $$\text{PBR} = \frac{(\text{Repaired units x 100}}{(\text{Units repaired + NRTS + condemned})}$$

Example: $$\text{PBR} = \frac{(6 \times 100)}{(6 + 4 + 2)} = 50\% \text{ or } .50$$

b. Consumption/Expendable Type Item. Items which are consumed in use or which lose their identify through incorporation in or attachment to another assembly.

c. Daily Demand Rate (DDR). The Daily Demand Rate is the average quantity used daily and is computed internally using one of the following methods:

(1) If the item is a bachelor or substitute: The cumulative recurring demands are divided by the difference of the current Julian date minus the Date Of First Demand (DOFD).

(2) If the item is a master or interchangeable: The cumulative recurring demands are accumulated for the master and all interchangeables within the group (for one system designator at a time). The sum is divided

by the difference of the current Julian date minus the oldest date of first demand in the master/interchangeable group.

NOTE: If less than 180 days of demand experience is available, a difference of 180 days is assumed in order to minimize the inflationary effect of limited demand experience. This procedure applies to either the bachelor/substitute method or the master and interchangeable method of computation.

$$\text{Formula: DDR} = \frac{\text{Cumulative Recurring Demands}}{\text{Current Date - DPFD}}$$

$$\text{Example: DDR} = \frac{12}{365} = 0.0328$$

d. Depot Condemnation Rate. The percentage of failed units that are received at the depot that will be condemned. This fraction is not a percentage of total base level generations.

e. Expected Backorders. The expected number of unfilled demands existing at the lowest echelon (bases) at any point in time. The expected number of "holes" in the aircraft, missile, communication equipment, or other defense system.

f. Fill Rate. The percentage of demands that the supply activity at the lowest echelon is able to fill without delay from on-hand stock.

g. Indenture. A term used to indicate an order of dependence when items are broken down into assemblies, subassemblies, components, and parts. A lower indenture item is part of the next higher assembly.

h. Initial Operational Capability. The first attainment of the capability to effectively employ a weapon, item of equipment or system to approved specific characteristics which is manned or operated by an adequately trained, equipped and supported military unit or force.

i. Initial Provisioning. The process of determining the range and quantity of items required to support and maintain an end item/article of material for an initial period of operation. Its phases include identifying items of supply, establishing data needed to prepare catalogs, technical manuals and tables of allowances; and preparing instructions that assure delivery of necessary support items with related end articles.

j. Initial Spares Support List (ISSL). A list of spares and repair parts and quantities required for organizational and field maintenance of an end item for a give period of time. Quantities established for ISSLs will be equal to the initial base stockage objective.

k. Line Replaceable Unit (LRU). Any assembly which can be removed as a unit from the system at the operating location. This may include avionics, hydraulics, pneumatics, and other recoverable parts. The models presented here view an engine as an LRU and some of the examples may use the terms LRU and engine interchangeably.

l. Mission Capability (MICAP). An item without which the aircraft cannot fly, or complete its mission.

m. Multi-Echelon Technique for Recoverable Item Control (METRIC). A single-indentured technique developed by RAND Corporation.

n. MOD-METRIC. A multi-echelon technique developed at AFLC for use on items of more than one indenture to explicitly consider the LRU-SRU relationship.

o. Mean Time Between Demands (MTBD). The average number of operating hours accumulated on a unit when it is removed from a next higher assembly and a request is made for a replacement from supply.

p. Not Mission Capable Supply (NMCS). Item not available for installation on an aircraft from available stocks.

q. Not Reparable This Station (NRTS). The percentage of failed items which must be sent to a central repair activity having greater repair capabliity.

r. NRTS/Condemned Quantity (NCQ). The NRTS/Condemned Quantity represents the number of units required for the NRTS/Condemnation processing time.

s. NRTS/Condemned Time (NCT). The NCT is the average number of days to complete the NRTS/condemnation process. This figure is computed by dividing the sum of the current plus 1st, 2nd, and 3rd previous quarters of NRTS/condemned days by the sum of the current plus 1st, 2nd, and 3rd previous quarters of the number of units turned in condemned and NRTS.

t. Order and Shipping Time (O&ST). The Order and Shipping Time is the average elapsed time, in days, between the initiation and receipt of stock replenishment requisitions.

u. Order and Shipping Time Quanitity (O&STQ). Order and Shipping Time Quantity is the quantity required to meet demands during the Order and Shipping Time.

v. Organic Repair Capability. The capability to perform all test and repair functions on reparable assets at an Air Logistics Center.

w. Preliminary Operational Capability (POC). The attainment of the capability for equipment or systems to be used by operational units and to function in a manner that is preliminary to, but in support of, the achievement of an Initial Operational Capability (IOC).

x. Procurement Cycle/Safety Level (PC/SL). A three month period of support designed to provide some protection against unexpected occurrences/demands. PC/SL in combination with the Procurement Lead Time Support Quantity is the item support period initial requirement for the Program Forecast Period.

y. Production Asset. A new part or subassembly procured by ASD for the express purpose of installation on an aircraft prior to the aircraft's release from the production facility.

z. Recoverable or Reparable Type Items. An item of durable nature, which, when unserviceable, normally can be repaired economically either by a field or depot maintenance activity.

aa. Repair Asset. A part or subassembly which has failed and been returned to the vendor or the depot for repair.

bb. Repair Cycle. All the stages through which a reparable type item passes from the time of its removal as unserviceable until it is restored to a serviceable condition.

cc. Repair Cycle Quantity (RCQ). The Repair Cycle Quantity represents the number of units that must be stocked to meet demands during the repair cycle. In brief, this quantity varies according to the success of the base repair program. The computation of the repair cycle quantity requires the determination of average percent of base repair and the determination and/or application of the repair cycle time.

dd. Safety Level Quantity (SLQ). Safety Level Quantity are those assets required to be on hand to permit continuous operation in the event of a minor interruption of the normal replenishment cycle or unpredictable increases in demands.

ee. Shop Replaceable Unit (SRU). A module for an LRU which can be removed from the LRU at an intermediate repair facility.

ff. Spare Asset. A new part or subassembly procured and placed in the supply system, intended to replace like items which have failed on an aircraft.

gg. War Readiness Materiel (WRM). That material required to augment peacetime assets to completely support forces, missions, and activities reflected in USAF War Plans.

APPENDICES

APPENDIX A

LOGISTICS MODELS

(A) <u>DO28</u>

<u>Title</u>: Air Force Recoverable Central Leveling System (Draft)

<u>Directive</u>: DO28 Systems Specification #SS-D-10038-B (9)

Takes the world-wide repair cycle asset requirements generated by the DO41 computer system and compares them to actual assets available to determine order quantities and specific base allocations (20).

(B) <u>DO29</u>

<u>Title</u>: War Readiness Spares Kit/Base Level Self Sufficiency Computation System (Draft)

<u>Directive</u>: DO29 Systems Subsystems Specification #SS-D-10039-A

Determines War Reserve Spares Kit and Base Level Self Sufficiency stock quantities based on unit flying hour programs, unit equipment, and the organizational maintenance capability (10).

(C) <u>D040</u>

<u>Title</u>: War Reserve Materiel Lists/Reqiurements & Initial Spares Support Lists

<u>Directive</u>: AFM 67-1, Vol I, Pt 1, Chapter 12 and 14; AFLCM 171-300; AFLCR 57-18

Utilizes automatic file maintenance to provide SM and IM with update products for management and control of War Readiness Materiel Lists and Initial Spares Support Lists (WRM/ISSL); provides cross-reference index of WRM/ISSL serial numbers to appropriate aircraft or equipment applications supported and provides data to

various requirements computation systems and higher headquarters for computation and surveillance of those quantities of consumable War Readiness Materiel specified in current plans (15).

(D) D041

Title: Recoverable Consumption Item Requirements System

Directive: AFLCM 57-4

Operates expendable Investment Recoverable Spares Computations, utilizes AF programming data, authorizations and world-wide on-hand/due-in assets, and other requirements and asset data to determine gross and net item requirements, procurement programs, and budget estimates. Outputs are used by the operating divisions to initiate buy, repair, termination - disposal action, etc., as appropriate. Output product is used by ALC/AFLC staff personnel to forecast budget requirements to higher echelons (15).

(E) D062

Title: Economic Order Quantity, Buy Computation System

Directive: AFLCM 57-6; AFLCM 171-51

The EOQ Buy Computation System computes wholesale stock levels and materiel requirements for all centrally procured items identified by ERRC codes XB and XF3. This system is run twice monthly on the 15th and 30th of each month using the most current asset, demand, interchangeability and substitution, and stock list data. The requirement forecasting technique used is based primarily on the demand concept that future requirements are based upon past demands. The

system employs a "management by exception" philosophy, in that computation worksheets are output to the Item Manager for review and action only when item asset positions breach computed action levels or when an interrogation has been submitted (15).

(F) H028

Title: Foreign Military Sales and Grant Aid Program

Directive: AFLCM 171-238; AFM 177-112

Provides procedures necessary for operation and maintenance of the Foreign Military Sales and Grant Aid. Provides accounting and management data and reports required to insure USAF reimbursement for material and services provided eligible foreign governments (15).

(G) H051

Title: International Logistics, Program Centralized Accounting and Reporting System

Directive: AFLCM 171-93; AFM 177-120, Chapters 5 and 7; AFR 400-3; AFLCR 400-23

Provides for establishment and maintenance of program and requisition control of Foreign Military Sales and Grant Aid. In addition, provides for computer standard pricing and routing of all requisitions, maintains all Military Standards Requisitions and Issues Procedures Status, and provides supply and performance report to higher authority, foreign governments, Military Assistance Advisory Groups/Missions, Single Point Managers, and Headquarters, Air Force

Logistics Command (15). To be replaced the Security Assistance Management Information System (SAMIS).

(H) METRIC

Title: Multi-Echelon Technique for Recoverable Item Control

Directive: AFLCM 57-4

A mathematical model of a base-depot supply system in which item demand is compound Poisson with a mean value estimated by a Bayesian procedure. When a unit fails at base level there is a probability that it can be repaired at the base according to an arbitrary probability distribution of repair time, and a probability (1 - r) that it must be returned to the depot for repair according to some other arbitrary distribution. No lateral resupply between bases is considered in the model. For high-cost, low-demand items the appropriate policy is (s-1, s), which means that items are not batched for repair or resupply requests. This problem has a simple analytic solution that is a function of the mean repair times rather than the repair time distributions. METRIC compensates for the shortcomings at the conventional pipeline and base stockage models for recoverables by considering multiple items at multiple bases at both the base and the depot level (42).

(I) MOD-METRIC

Title: Modified Multi-Echelon Technique for Recoverable Item Control

Directive: AFLCP 57-13

This program, as the name implies, is a modified METRIC program which considers the interrelationship between line replaceable units (LRU) and shop replaceable units (SRU), and computes the effect of SRU stock levels on LRU availability. When an LRU fails, avionics test stations determine which SRUs have failed within the LRUs. Maintenance personnel then remove and replace the defective SRUs and return the LRU to base supply. The smaller and less expensive SRUs are then sent through the pipeline for repair. Since an aircraft can be grounded by the lack of either very expensive or inexpensive items, MOD-METRIC will consider the increase in support returned per additional dollar invested. It then incorporates this marginal analysis in allocating money to the various LRUs and SRUs. MOD-METRIC considers several variables during its computation of the optimal SRU and LRU levels. These variables are the flying hour program, maintenance and demand frequencies, component process, the number of bases, repair and pipeline times, and the target FMC rate, all subject to budgetary constraints.

The objective of MOD-METRIC is to determine the optimal base and depot stock levels of LRUs and SRUs to minimize total expected base level backorders, subject to an investment constraint. The MOD-METRIC model does this while operating under several assumptions:

(1) A stationary compound Poisson probability distribution describes the demand process for each item.

(2) There is no lateral base resupply.

(3) A failure of one type of item is statistically independent of those that occur for any other type of item.

(4) Repair times are statistically independent.

(5) There is no batching of items before repair is started. (Infinite channel queuing)

(6) The repair level is based on the complexity of repair and not on the existing workload.

(7) No cannibalizations take place.

In the MOD-METRIC model attention is restricted to a single LRU and its subordinate SRUs. However, by the use of marginal analysis, MOD-METRIC can be extended to compute stock levels for a number of LRU groups simultaneously (3).

APPENDIX B

INITIAL PROVISIONING FORMULATION

These factors form the baseline for initial requirements generation (8:6).

<u>Maintenance Factor</u>. The maintenance factor is the anticipated average maintenance replacement rate per program unit (100 hours of operation in the D041 computer system). The replacement of the item must create a demand on supply for a like item. The demand on supply (or mean time between demand (MTBD) excludes line repair and other non-demand failures (8:2). Although the manufacturer supplies the Air Force with MTBF estimates, attempts to use these estimates to forecast initial spare requirements consistantly results in underpredicted values (8:8). This is because the manufacturer does not quantifiably consider parameters such as the operational environment, the maintenance learning curve, or the ratio of operating hours to flying hours (8:8-9). The equipment specialist will consider these factors (called K-factors), and apply them to the design MTBF to obtain a MTBD. K-factors are applied in the following fashion:

$$MTBD = \frac{\text{Design MTBF}}{K_1 \times K_2 \times K_3 \times K_4}$$

Where:

K_1 = the ratio between the specified MTBD and the minimum acceptable MTBF. This K-factor is identified in the end item contract as a reliability requirement.

K_2 = the difference between predicted design failures and actual operational failures.

K_3 = The ratio of operating hours to flying hours.

K_4 = The ratio of demand on supply for an item to item failure. Not all failures will generate a remove and replace action and a demand for a spare.

The maintenance factor is developed by dividing the derived MTBD into 100 hours (a program unit). This factor is then multiplied times the total number of program units (flying hour program divided by 100) to obtain the gross number of item replacements needed.

Example:

MTBD = 500 hours

Initial support period flying hour program = 25,000 hours

$$\frac{\text{100 hours (program unit)}}{\text{500 hours (MTBD)}} = \text{.2 (maintenance factor)}$$

Application:

$$\frac{\text{25,000 hours (flying program)}}{\text{100 hours (program unit)}} = \text{250 program units}$$

(250 program units) x (.2 maintenance factor) = <u>50 gross replacements</u>

This example involves a single component within a single next higher assembly (NHA). For multiple applications of the same component within a single NHA, individual maintenance factors per components are determined, then averaged and applied as a uniform rate. To determine maintenance factor rates for multiple component applications within multiple next higher assemblies, first multiply the QPA of the items times the number of NHAs installed. Then multiply this number times the rate within a single NHA, total the results, and divide by the sum of all installed QPAs.

Example:

Develop the average maintenance factor for a rod bushing that has multiple QPAs within the following NHAs:

Gyroscrope. . . . . . . 3 QPA
Stab Actuator . . . . . 4 QPA
Throttle Quadrant. . . . 5 QPA

Solution:

	Bushing QPA	x	# NHA per aircraft	=	Installed QPA	x	Average Maintenance factor per QPA	=
Gyro	3		6		18		.2	3.6
Stab	4		2		8		.3	2.4
Throttle	5		2		+10		.4	+4.0
					36			10.0

36 ÷ 10 = 3.6 failure removals per QPA program increment.

Base Condemnation Percent. The base condemnation percent is assigned to items repair coded F (field repair) which are removed and processed for intermediate level repair, and are subsequently condemned at that level (8:8).

Depot Condemnation Percent. The depot condemnation percent is the percent of repair parts and next higher assemblies that will be condemned during depot overhaul. For repair parts coded B or Z (recondition or no repair), condemnations always equals replacements, and depot condemnation is 100%. For assemblies used in the repair of a next higher assembly (non-job-routed), the depot condemnation percent is the percent of replaced items that will be condemned. For assemblies routed separately as depot overhaul items (job-routed), the depot condemnation percent is that percent of the replaced items (8:3).

NRTS Percent. The NRTS rate is that portion of the estimated reparable generations which intermediate shops cannot repair, and must be forwarded to the depot. During initial provisioning, the NRTS rate is applied only to items repair coded D.

Once the maintenance factor, the overhaul replacement percent, the base condemnation percent, the depot condemnation percent, and NRTS percent are developed, the actual quantities of items to be provisioned are determined in accordance with AFLCR 57-27. The actual quantity to be provisioned is determined by computing buying and operating requirements, as well as repair requirements. Buying and operating requirements consist of the following:

(A) Procurement Cycle/Safety Level. This is a three month requirement which equals:

$$PC/SL = 3 \text{ Mos} \times AMP \times W/O \text{ rate} \times QPA \tag{1.2}$$

Where: 3 mos = 3 months

AMP = Average month's quantity serviced

W/O = Wearout rate

QPA = Quantity per application, and

$$W/O \text{ rate} = (NRTS \% \times \text{depot condemnation } \% \text{ (DCP)}) + (1.00 - NRTS \% \times \text{base condemnation } \%) \tag{1.3}$$

(B) Lead time. Lead time requirements are computed as:

$$\text{Lead time} = PLT \times AMP \times W/O \text{ rate} \times QPA \tag{1.4}$$

Where: PLT = procurement lead time

(C) Depot Repair Cycle. The depot repair cycle requirement is computed as:

$$\text{Depot Repair Cycle} = DRC \times AMP \times QPA \times \text{Depot DR} \tag{1.5}$$

Where: DRC = depot repair cycle

Depot DR = Depot demand rate

(D) Base Repair Cycle. The base repair cycle quantity is computed as:

$$\text{Base Repair Cycle Quantity} = BRC \times \text{Peak} \times QPA \times BRR \tag{1.6}$$

Where: BRC = base repair cycle

Peak = peak month stock level

BRR = base repair rate

(E) Base Order and Shipping Time. The Base O&ST quantity is computed as:

$$\text{Base O\&STQ} = \text{O\&ST} \times \text{Peak Usage} \times \text{QPA} \times \text{OIM} \tag{1.7}$$

Where: O&ST = order and shipping time

OIM = organizational-intermediate depot demand rate

and: $$\text{OIM} = ((\text{Maint Fac} \times \text{NRTS \%}) + (\text{Maint Fac} \times (1.00 - \text{NRTS \%}))) \times \text{Base condemnation \%} \tag{1.8}$$

(F) Base Stock Level Requirement. This is the sum of the base repair cycle requirement and the base O&ST requirement. This is also known as the world-wide ISSL requirement.

Requirements (A) through (F) are summed to determine the total buying and operating requirement. The second type of requirements are repair requirements, which are segregated into job-routed (JR) and non-job-routed (NJR). Repair requirements are computed by first deriving the following quantities:

(A) Procurement Cycle/Safety Level.

For JR programs: $$\text{PC/SL} = \text{DCP} \times \text{AMP} \times \text{QPA} \times 3 \text{ mos} \times \text{OR \%} \times \text{W/O rate} \tag{1.9}$$

Where: OR % = overhaul replacement percent

DCP = depot condemnation percent

For NJR programs: $$\text{PC/SL} = ((1.00 - \text{DCP}) \times \text{AMP} \times \text{QPA} \times 3 \text{ mos} \times \text{DCP}) \tag{1.10}$$

(B) Lead Time.

For JR programs: $$\text{Lead time} = \text{AMP} \times \text{QPA} \times \text{DCP} \times \text{PLT} \times \text{W/O rate} \tag{1.11}$$

For NJR programs: $$\text{Lead time} = AMP \times QPA \times (1.00 - DCP) \times PLT \times DCP \tag{1.12}$$

(C) <u>Depot Repair Cycle</u>.

For JR programs: $$\text{Depot RC} = DCR \times AMP \times QPA \times (1.00 - DPC) \times \text{W/O rate} \tag{1.13}$$

For NJR programs: $$\text{Depot RC} = DRC \times AMP \times QPA \times (1.00 - DCP) \times DCP \tag{1.14}$$

(D) <u>Stock Level</u>.

For JR programs: $$SL = (AMP \times QPA \times DCP) \div (30 \text{ days} \times SL \text{ days}) \tag{1.15}$$

For NJR programs: $$SL = (AMP \times QPA \times (1.00 - DCP)) \div (30 \text{ days} \times SL \text{ days}) \tag{1.16}$$

The values obtained for (A) through (D) are then summed and added to the buying and operating requirement. This total represents the quantity to be initially provisioned by the Air Force. WRM requirements may be added to this total if so authorized by AFLCR 57-18 (8:8-9).

APPENDIX C

WRSK/BLSS COMPUTATION

The Conventional Method.[7] A conventional WRSK is built using a table recognizing demands per day and the availability of assets coming out of maintenance. Factors used to contruct the table are: the Daily Flying Hour Program (DFHP), Total Demand Rates (TDR), Base Repair Rates (BRR), Base Repair Cycle days (BRC), and the Quantity Per Application (QPA). Each of these factors will be used in completing the table illustrated in Table C-1.

Table C-1

WRSK Table

Day	1	2	3	4	5	6	7	8	9	10
Demands										
Assets Available from Maintenance										
Cumulative Deficits										

The first line of the table reflects demand. Demand is dependent upon the DFHP, the demand rate, and the QPA. The DFHP is provided by HQ USAF. The demand rate is derived by counting the number of demands over a period of time, and dividing that number by the flying hours flown over that same period. The QPA is the number of items found on each aircraft. The formula to compute demands is:

$$\text{Demand rate} \times \text{DFHP} \times \text{QPA} = \text{Demands} \qquad (2.1)$$

Example:

The daily demands for an item having a demand rate of .005, a QPA of 1, and a DFHP of 2000 hrs on days 1-5 and 1000 hours on days 6-10 is computed and entered as follows:

Days 1-5: .005 x 2000 x 1 = 10 demands

Days 6-10: .005 x 1000 x 1 = 5 demands

[7]WRSK information is adopted from Appendix 18, DO29 Systems Subsystem Specification, Specification Number SS-D-10039A, 28 Jan 82.

Table C-2

WRSK Table

Day	1	2	3	4	5	6	7	8	9	10
Demands	10	10	10	10	10	5	5	5	5	5
Assets Available from Maintenance										
Cumulative Deficits										

If no maintenance capability exists, there are no assets available from maintenance and the cumulative deficit equals the sum of the daily demands. This is the case for items classified as Remove and Replace (RR) items. If a maintenance repair capability exists for an item, the item is a Remove, Repair, and Replace (RRR) item. Here, maintenance removes the failed item, replaces it with a serviceable one, and then repairs the failed item. If a maintenance capability exists, then less items are needed in the WRSK to avoid any stock due outs. For example, when the daily demand rate is 1, and the BRC is two days, two assets will be needed to support the operation, regardless of the deployment duration. On day three, the unserviceable item turned into maintenance on day 1 has been repaired and is available to satisfy day three's demand. Therefore, assets are only needed to fill the BRC.

In addition to when assets become available, the model considers how many will be available as serviceable assets, since not all failures are base reparables. Assuming that maintenance can only repair a portion of the demands, the number that can be repaired becomes dependent upon the BRR. The BRR is the number of demands repaired per flying hour. The number of "Assets Available from Maintenance" are computed as follows:

$$\text{BRR} \times \text{DFHP} \times \text{QPA} = \text{Assets Available from Maintenance} \qquad (2.2)$$

The assets going into maintenance during the maintenance set-up time (MX SUT) and the first day maintenance is operational will become available to satisfy demands on Day X, where:

$$\text{Day X} = \text{MX SUT days} + \text{BRC days} + 1 \tag{2.3}$$

Thus, given a 2 day MX SUT and a 2 day BRC, assets will first be available on day 5.

Going back to Table C-2, if the BRR is .004, the MX SUT is 2, and the BRC is 2, the assets available on day 5 are equal to:

$$\text{BRR} \times \text{QPA} \times \sum_{i=1}^{\text{MX SUT}+1} (\text{DFHP})_i = \text{Assets Available} \tag{2.4}$$

$$.004 \times 1 \times 6000 = \underline{\underline{\text{24 Assets Available day 5}}}$$

and all subsequent maintenance releases are determined by the formula:

$$\text{BRR} \times \text{QPA} \times \text{DFPH} = \text{Assets Available on day X} + \text{BRC days} \tag{2.5}$$
(where X = any day after MX SUT + 1.)

Thus, when:

X = 4 $\quad .004 \times 1 \times 2000 = 8$ Assets Avail on day 6
X = 5 $\quad .004 \times 1 \times 2000 = 8$ Assets Avail on day 7
X = 6 $\quad .004 \times 1 \times 1000 = 4$ Assets Avail on day 8
. .
. .
. .
X = 10 $\quad .004 \times 1 \times 1000 = 4$ Assets Avail on day 12

The table then becomes:

Table C-3

WRSK Table

	Day	1	2	3	4	5	7	8	9	10
Demands		10	10	10	10	10	5	5	5	5
Assets Available from Maintenance		0	0	0	0	24	8	8	4	4
Cumulative Deficit										

The number of assets required in the conventional WRSK is the greatest cumulative deficit over the WRSK support period, plus a safety level. The greatest cumulative deficit is computed by subtracting the daily assets available from maintenance from the daily demand to determine the deficit for each day. These are then summed to compute the cumulative deficit on each day, with the largest value becoming the greatest cumulative deficit (GCD).

Table C-4

WRSK Table

	Day	1	2	3	4	5	6	7	8	9	10
Demands		10	10	10	10	10	5	5	5	5	5
Assets Available from Maintenance		0	0	0	0	24	8	8	4	4	4
Cumulative Deficit		10	20	30	40	26	23	20	21	22	23

greatest cumulative deficit

A safety level equal to the square root of the greatest cumulative deficit is then added to the deficit level to determine the WRSK stock level for that item.

$$\text{WRSK Stock Level} = \text{GCD} + \sqrt{\text{GCD}}, \text{ rounded}^{8} \tag{2.6}$$

$$40 + \sqrt{40} = 46.325$$

The Marginal Analysis Method. The Marginal Analysis (MA) WRSK is designed to give the same support as the conventional kit. To build an MA WRSK, a conventional WRSK is computed, then evaluated in terms of two parameters, the SDO and NMC goals. Once these goals are determined, a new kit is built by adding in order those items which provide the greatest reduction in these two parameters for the money spent.

Let's first examine the SDO. In the MA WRSK computational model, the probability of expected shortages is determined using a Poisson distribution. Using the probabilities from the Poisson distribution function for the expected number of failures to occur, the model computes the expected shortages given the number of assets installed in the kit. For example, if there are no assets in the kit, and there exists a mean demand of 2, we can expect to be 2 assets short. This is determined by the relationship:

$$E(SDO) = \sum_{x=n}^{QPA + UE + n} (x - n)p(x); \tag{2.7}$$

Where n = number of items in the WRSK

[8]Rounding is accomplished by adding .5 to the final figure, then dropping the value after the decimal point. This method is used in both WRSK and BLSS.

This formula is constructed so that the sum of the E(SDO) cannot exceed the total of the components installed in the aircraft deployment package and the items installed in the kit.

Example: Determine the E(SDO) for an item with a mean demand of 2, with zero assets in the WRSK, for a 3UE package, where item QPA = 2.

Solution: $E(SDO)_0 = OP(0) + P(1) + 2P(2) + 3P(3) + 4P(4) + 5P(5) + 6P(6) + 7P(7)$

$$E(SDO)_0 = O + (1 \times .2707) + (2 \times .2707) + (3 \times .1805) + (4 \times .0902) + (5 \times .0361) + (6 \times .0102) + (7 \times .0034) = \underline{\underline{1.9799}}$$

The computation process is then continued to define the expected improvement in the SDO given that one item is now placed in the kit.

$$E(SDO)_1 = OP(0) + OP(1) + P(2) + 2P(3) + 3P(4) + 4P(5) + 5P(6) + 6P(7) = \underline{\underline{1.1181}}$$

Continuing with 2, 3, 4, 5, and 6 items in the WRSK:

$E(SDO)_2 = .4851$	$E(SDO)_5 = .0188$
$E(SDO)_3 = .2120$	$E(SDO)_6 = .0034$
$E(SDO)_4 = .0703$	$E(SDO)_7$ = Effectively Zero

After the E(SDO) values are determined, a decision must be made as to which items will be added to the WRSK. Assume a kit consists of three line items: A, B, and C, where each has a mean demand of 2 and costs \$100, \$500, and \$1000 respectively. In the conventional kit design, two of each would be placed in each kit, giving a total SDO of 3 x .4851 = 1.4553, at the cost of \$3200. The model then tries to determine if the same SDO can be achieved at a lower cost. The model determines this computing the SDO

reduction per dollar spent for each item. ranking them according to reduction per dollar, and continuing until the SDO goal is met. The SDO reduction is computed as follows:

$$\frac{SDO_i - SDO_{i+1}}{\text{Unit Cost}} = \text{SDO improvement per dollar;} \qquad (2.8)$$

Where $SDO_i - SDO_{i+1}$ is the improvement in SDOs when 1 more unit of part i is placed in the kit.

First, the SDO improvements are computed for adding components:

add 1 = 1.9799 - 1.1181 = 0.8618
add 2 = 1.1181 - 0.4851 = 0.6330
add 3 = 0.4851 - 0.2120 = 0.2731
add 4 = 0.2120 - 0.0703 = 0.1417
add 5 = 0.0703 - 0.0188 = 0.0515
add 6 = 0.0188 - 0.0034 = 0.0154

Next, a chart is constructed showing the SDO improvement per dollar cost for each unit added:

Units	A	B	C
1	.0086	.0017	.0009
2	.0063	.0013	.0006
3	.0027	.0005	.0003
4	.0014	.0003	.0001
5	.0005	.0001	.0001
6	.0001	.0000	.0000

Finally, a new kit is formed by rank ordering components with the largest improvement per dollar cost until the desired E(SDO) is reached:

WRSK Composition	Add	Cost	SDO reduction	E(SDO)
Initially	0	0	0	6
0	A	100	.8618	5.1382
A	A	200	.6330	4.5052
A,A	A	300	.2731	4.2321
A,A,A	B	800	.8618	3.3703
A,A,A,B	A	900	.1417	3.2286
A,A,A,A,B	B	1400	.6330	2.5956
A,A,A,A,B,B	C	2400	.8618	1.7338
A,A,A,A,B,B,C	B	$2900	.2731	1.4607
A,A,A,A,B,B,B,C	-			

In this example, a kit with four of item A, three of item B, and one of item C gives a lower SDO (1.4607) at $300 less than the conventional kit.

The other parameter in the MA WRSK computation is the NMC rate. This parameter controls the concentration of shortages from falling into a single or few line items. A concentration of MA induced shortages in a few line items could result in relatively few shortages at the expense of many aircraft.

The expected number of NMC aircraft is computed using a Poisson distribution for zero aircraft all the way through the total deployed number of aircraft. The model then computes the average value of the expected NMC aircraft using the same method used to compute E(SDO). One item will then be added to the kit and all computations are redone to determine the new NMC value. The item is then taken out of the kit, another one added, and the procedure is repeated. This is done for every item in the kit so that the NMC improvement for each item is identified. The improvement is divided by the unit cost to determine the improvement per dollar. This

method assumes cannibalization when QPA is greater than 1, and consolidates multiple demands for like items accordingly. The E(NMC) is computed using the following relationship:

$$E(NMC) = UE - \sum_{X=0}^{UE-1} \prod_{i=1}^{Total} Q_i\,(n + QPA \times X); \qquad (2.9)$$

Where: UE = Unit equipment

Q_i = Poisson probability of failure of component i

n = Stock level of items per WRSK

X = Number of failures

This relationship is then used to determine which item to add to the kit next to provide the most reduction in E(NMC) per dollar spent.

The last remaining formula combines the two parameters to select the item that gives the best combined benefit per dollar cost. That formula is:

$$\frac{\Delta E(SDO) + A\Delta E(NMC)}{\text{Unit Cost}}; \qquad (2.10)$$

Where: Δ is the improvement in SDO and NMC when one additional item is added to the kit, and

"A" is a weighing factor

Experience has shown that as items are added one at a time without a weighing factor, the SDO goal is met well ahead of the NMC goal, thus increasing computer processing time. Therefore, the MA technique assigns a weighting factor and a speed-up factor to approach both goals simultaneously. MA WRSK adjustments will never drop below the fixed safety level for a conventional WRSK.

Base Level Self-Sufficiency Spares Computation[9]

BLSS assets are computed on a daily basis using a table which recognizes daily demands, assets coming out of base repair and order and shipping time pipelines. This table is depicted as Table C-5 below.

Table C-5

BLSS Table

Total Wartime Requirements

	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demands															
Out of Base Repair															
Out of O&ST															
Deficit															
Cumulative Deficit															

The table values are computed as follows:

(a) Demand = Total demand rate (TDR) x DFHP x QPA. (2.1)

(b) Out of Base Repair = BRR x DFHP x QPA. (2.2)

(c) Out of O&ST = Depot Demand Rate (DDR) x DFHP x QPA. The day assets come out of O&ST equals the day of demand plus the O&ST time. (2.11)

(d) Deficit = Demands - (assets out of base repair + assets out of O&ST). (2.12)

(e) The cumulative deficit is used to find the total wartime requirement (GCD) for the BLSS support period. This is the same concept that was used to identify the GCD during the conventional WRSK computation.

[9] Adapted from Appendix 19, D029 Systems Subsystem Specification, Specification Number SS-D-10039A, 28 Jan 82.

For example, when the following set of conditions exist:

TDR = 5.0

BRR = 4.0

DDR = 1.0

QPA = 1

BRC = 4 days

O&ST = 10 days

$DFHP_{peace} = 1.0$

$DFHP_{war\ day\ 1\text{-}7} = 3.0$

$DFHP_{war\ day\ 8\text{-}end} = 2.0$

The total wartime requirement table would be filled in as follows:

Table C-6

Total Wartime Requirements

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demands	15	15	15	15	15	15	15	10	10	10	10	10	10	10	10
Out of Base Repair	0	0	0	0	12	12	12	12	12	12	12	8	8	8	8
Out of O&ST	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3
Deficit	15	15	15	15	3	3	3	+2	+2	+2	+5	+1	+1	+1	+1
Cumulative Deficit	15	30	45	60	63	66	69	67	65	63	58	57	56	55	54
							GCD								

A safety stock is added to the GCD as it was in the WRSK. Recalling formula 2.6 will provide the total wartime BLSS requirement:

$$\text{Total} = \text{GCD} + \sqrt{\text{GCD}}, \quad \text{rounded off} \tag{2.6}$$

$$69 + \sqrt{69} \ \text{(rounded)} = 77$$

The next step in computing the BLSS requirement is the computation of the peacetime assets that will be available on the base on D-Day, the POS offset. The POS offset is computed as:

$$\text{POS Offset} = \text{BRR} \times \text{DFHP}_{\text{peace}} \times \text{QPA} \times \text{BRC} \tag{2.13}$$

The peacetime safety level is the square root of three times the total of the POS offset quantity and the O&ST pipeline, where:

$$\text{O\&ST Pipeline} = \text{DDR} \times \text{DFHP}_{\text{peace}} \times \text{QPA} \times \text{O\&ST days} \tag{2.14}$$

so that:

$$\text{Peacetime Safety Level} = \sqrt{(3) \times \text{POS offset} \times \text{O\&ST pipeline}} \tag{2.15}$$

Therefore, a new peacetime offset is generated, one which contains a safety level. This new offset is computed as:

$$\text{Total Peacetime offset} = \text{POS offset} + \sqrt{(3) \times (\text{POS Offset}) + (\text{O\&ST pipeline})} \tag{2.16}$$

In this example, the total peacetime offset equals:

$$16 + \sqrt{3(16 + 10)} = 25 \quad \text{(rounded)}$$

In the overseas safety level computations, BLSS uses a 2 outside the radical to coincide with peacetime. For this example, the peacetime safety level would equal:

$$2\sqrt{3(16 + 10)} = 18 \text{ (rounded)}$$

And the peacetime offset would equal:

$$16 + 2\sqrt{3(16 + 10)} = 34 \text{ (rounded)}$$

The BLSS quantity, then, equals the total wartime requirement including safety level minus the rounded peacetime offset including safety level. Using the example for non-overseas bases:

$$\text{BLSS quantity} = (69 + \sqrt{69}) - 16 + \sqrt{3(16 + 10)} = 77 - 25 = 52 \text{ assets (rounded)}$$

And using the overseas example:

$$\text{BLSS quantity} = (69 + \sqrt{69}) - 16 + (2\sqrt{3(16 + 10)}) = 77 - 34 = 43 \text{ assets (rounded)}$$

APPENDIX D

REPAIR CYCLE ASSET COMPUTATION

The Repair Cycle Demand Level[10] is computed as follows:

$$\text{Repair Cycle Demand Level} = RCQ + O\&STQ + NCQ + SLQ \qquad (3.1)$$

Where:

$$RCQ^{11} = \begin{array}{l}\text{Daily Demand Rate (DDR) x}\\ \text{Percent Base Repair (PBR) x}\\ \text{Repair Cycle Time (RCT)}\end{array} \qquad (3.2)$$

$$O\&ST = DDR \times (1.00 - PBR) \times O\&STQ \qquad (3.3)$$

$$NCQ = DDR \times (1.00 - PBR) \times NCT \qquad (3.4)$$

$$SLQ = 3 \times \sqrt{(RCQ + O\&STQ + NCQ)} \qquad (3.5)$$

Demand levels will be maintained for any item demanded at least twice over the past 18 months, and whose daily demand frequency rate (DDFR) is greater than .0054.

$$DDFR = \frac{\text{number of demands during the past 18 months}}{\text{(Julian date of 1st demand during past 18 months) - (Current Julian Date)}} \qquad (3.6)$$

A zero demand rate is assigned when the DDFR is less than .0054 and the last demand date is greater than 180 days ago. A demand rate of one is assigned when the last demand date is less than 180 days ago, but the DDFR is still less than .0054.

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[10] Adopted from AFM 67-1, Vol II, Part One, 18 May 81, pgs II-1 thru II-8.

[11] See Glossary for explanation of variables.

APPENDIX E

ITEM MANAGER QUESTIONS

1. Do you attempt to consolidate the investment item requirements that are generated by the various demand sources?

2. Is the final usage of each item identified to you when the requirement order is placed?

3. Do you feel the Air Force generates relatively accurate asset requirement forecasts?

4. Do you experience problems with contractors failing to provide spare and repaired items on time?

5. Have you experienced problems with establishing distribution priorities once you receive items? How do you rectify these problems?

6. Would a consolidated demand forecast (not a contract commitment) be helpful to you? Why/Why not?

7. If there was one improvement you could make in the item procurement process, what would it be?

APPENDIX F

MANUFACTURER QUESTIONS

1. Who are your customers (Air Force, prime contractors, etc)?

2. What is the frequency that you receive parts orders?

3. What are typical representative delivery rates requested on the orders?

4. Do you feel the Air Force generates relatively accurate asset requirement forecasts?

5. Do you generate independent, internal demand forecasts? What factors do you use? How do your forecasts compare to the Air Force? How do you reconcile differences?

6. Have you ever experienced problems with delivery priorities? How do you resolve these conflicts?

7. Would a consolidated requirement forecast (not a contractural commitment) be helpful to you? Why/Why not?

8. If there were one aspect of the parts ordering process you could change, what would it be?

9. Would you prefer to remain anonymous?

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